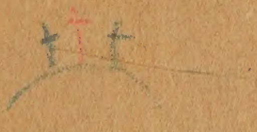
IN PURSUIT OF TRUTH

A COMPARATIVE STUDY IN SCIENCE AND RELIGION

By Alex. Wood, M.A., D.Sc.

Fellow and Tutor of Emmanuel College and Lecturer in Experimental Physics in the University of Cambridge

Modern scientific thought throughout its progress has created problems for religious belief which to-day are more than usually insistent. This book is written on the assumption that the main barrier between science and religion at present is a wrong attitude of mind based on misconceptions of the true nature of science and the true nature of religion



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BY
ALEX. WOOD
M.A. (CANTAB), D.SC. (GLASGOW)
Fellow and Tutor of Emmanuel College and Lecturer in Experimental Physics in the University of Cambridge

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PREFACE

This little book makes no claim to originality. It is an attempt to restate, as simply as possible, that view of the nature and method of physical science which, while not altogether new, has recently received such widespread recognition and support that it seems to belong essentially to our own time. The book demands very little knowledge of physical science, although here and there the references will be better understood by students of the subject. It is written on the assumption that the main barrier between science and religion at present is a wrong attitude of mind based on misconceptions of the true nature of science and the true nature of religion. This is an attempt to correct the former misconception and if, incidentally, it does anything to correct the latter misconception also, so much the better. In the bibliography the student who wishes to read more widely and more deeply will find sufficient guidance to enable him to make a start.

A. W.

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IN PURSUIT OF TRUTH

Chapter I

INTRODUCTORY

Ever since the beginnings of modern scientific thought its progress has created problems for religious belief. In our day these problems have assumed new forms, but they are still with us, and just because we are the children of an age which is pre-eminently scientific the problems are more than usually insistent. Our difficulties are increased by the wide dissemination of the results of scientific study, unaccompanied by any really effective criticism of its aims and methods such as would tend towards a genuine appreciation of what it pretends to be and to do. Scientific truth seems so eminently concrete and practical and verifies itself so obviously in our everyday life that we are apt to treat it as the only reliable kind of truth and the scientific method as the only reliable means of reaching truth. Now I hope it will appear in the sequel that the method of reaching theological truth is not so entirely different as we might at first sight be tempted to think, but we can only decide this question when we have made a careful analysis of the scientific method.

Clearly, we must approach the subject in an attitude of sincerity and with an earnest desire to know the truth. It is impossible for a student of the natural sciences—or indeed in these days for any student at all—to cultivate the compartmental mind. Sooner or later, and sooner rather than later, the partition will break down and the situation will have to be faced. There must be no skeleton in the cupboard. A story is told of a clergyman who was an enthusiastic amateur geologist. Happening one day to overtake a small girl who had picked up a fossil he stopped, and after examining it asked her how old she thought it was. "Oh, sir," she said, "about as old as the creation." "No, no," was the reply, "far older than that!" To the clerical compartment the creation took place in 4004 B.C.—to the geological compartment the fossil was the product of an agelong process.

Nor ought we to approach our subject in the attitude of fear. Nothing of real value can be lost by a courageous facing of the facts, and if religion is only a beautiful illusion, every vigorous mind will acquiesce in its speedy departure, even if the farewell is tinged with regrets. Nothing has done more harm to the cause of true religion than this attitude of fear. It has engendered a suspicion and distrust of new knowledge which is thoroughly unhealthy and begets in the public mind a lack of confidence which is by no means unjustifiable. Nor is there any historical ground for the fear. This is not the first appearance of the combatants in the ring, and religion has emerged from the earlier rounds in a wonderfully fresh condition. Indeed we should most of us agree that where the immediate battle was lost the ultimate advantage was with the vanquished. Does anyone now feel that the position which Gladstone tried to maintain against Huxley (the scientific accuracy of Genesis) was of real value to true religion ? " The Impregnable Rock of Holy Scripture " in Gladstone's sense of the term has been submerged in the sea of criticism, but we read these same Scriptures with more intelligence and more profit than before. We are as strongly convinced as ever of their intrinsic value and peruse the accounts of the Evolution trial in Tennessee with surprised incredulity.

Of course it is true that earlier controversies have been sectional engagements. They have raged around particular dogmas. They were concerned with the defence of territory which ought never to have been defended. The subjects were such that science had necessarily the last word. St Augustine has been quoted as saying : " It very often happens that there is some question as to the earth or the sky or the other elements of the world . . . respecting which one who is not a Christian has knowledge derived from most certain reasoning or observation, and it is very disgraceful and mischievous, and of all things to be carefully avoided that a Christian speaking of such matters as being according to the Christian Scriptures should be heard by an unbeliever talking such nonsense that the unbeliever, perceiving him to be as wide from the mark as east from west, can hardly restrain himself from laughing."[1]

If this is a genuine saying of St Augustine it is a pity it has remained buried for so long. The Christian Church would have avoided the advocacy of several lost causes if she had assimilated his wisdom. Questions of the movement of the earth and the method of creation would have been left to the scientist.

Religion is essentially an experience—theology is an intellectual interpretation of experience. Experience cannot be rendered intelligible either to ourselves or to others until we have given it some kind of intellectual formulation. This formulation may be very simple and elementary, as indeed it is in the case of many humble folk who are really great Christians; but something of the kind is indispensable. The interpretation ought to be related to our whole intellectual outlook, and it is here that science makes its impact. Our theology must be open to modification as science progresses. The danger of a refusal to modify is one of the lessons of the creation controversy. The first chapter of Genesis involves a theology adapted to harmonise with the science of the day. But the findings of science are never final. They are always open to review, and even the widely-held and generally-accepted conclusions of the science of our own day are not to be regarded as final. As Dr Fosdick has said: "The real enemies of the Christian faith are not the evolutionary biologists, they are those who insist on setting up artificial adhesions between Christianity and outgrown scientific opinions and proclaim that we cannot have the one without the other."

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[1] Quoted by Hobson, *The Domain of Natural Science*, p. 426.

Yet, while we condemn the timid and fearful attitude which so many good Christians adopt towards science, and while we regard it as groundless, our censure must be tempered with sympathy and understanding. They have made the discovery of a pearl of great price. It came to them in a particular dogmatic and ecclesiastical setting and they are not sure how much is gem and how much is setting. They do not realise that the skill of the craftsman has advanced and that the gem may be inserted in a worthier setting where it will harmonise all the better with its surroundings and be more resplendent than ever. Their concern for the gem is a worthy one and their distrust of those who would reset it is intelligible if indiscriminating. All the more so as the discoveries of science have often been shamefully exploited in a materialistic and anti-Christian interest. The general attitude of the counsel for the defence in the trial in Tennessee went far towards explaining the popular distrust of the theory of evolution in

America. The instinct of Uzzah (2 Samuel vi. 6) was at any rate a natural one and I shall continue to feel that he was hardly treated.

But the issue cuts deeper still. There are in all of us two opposite mental tendencies in varying proportion, the conservative and the radical, the priestly and the prophetic. The one desires above all things a relatively settled order, and is suspicious and fearful of all change ; the other is impatient of the old and eager for new views and new discoveries.

Both tendencies serve a useful purpose and both have their place—alike in science and religion—but the undue domination of either is fatal to true progress. In the sixteenth century the conservative tendency was undoubtedly in the ascendant. Scientific knowledge was regarded as complete and Galileo's astronomical discoveries were strongly resented. Indeed, when he turned his newly-discovered telescope to Jupiter and noted the attendant satellites, resentment became so strong that attempts were made to reason the new planets out of existence. One of these is worth quoting :

> " There are seven windows in the head, two eyes, two ears, two nostrils and the mouth : so in the heavens there are two favourable stars, two unpropitious, two luminaries and Mercury alone undecided and indifferent. From which and many other phenomena of nature, such as the

> seven metals, which it were tedious to enumerate, it follows that the number of planets is necessarily seven. Moreover, the satellites are invisible to the naked eye, and therefore can have no influence on the earth, therefore would be useless and therefore do not exist. Besides, the Jews and other ancient nations as well as modern Europeans have adopted the division of the week into seven days and have named them after the seven planets. Now if we increase the number of planets the whole system falls to the ground." (See Lodge, *Pioneers of Science*, p. 106.)

The only comment on this amazing piece of reasoning is the one which Galileo is reported to have made: "Whatever force these arguments may have as reasons for believing that only seven would be discovered, they hardly seem to have sufficient weight to destroy the new ones when actually seen."

It will readily be believed that if scientific knowledge was thus regarded as complete and final, religious dogma was in no better case. It was fixed and definite, a body of doctrine handed down from the fathers to be transmitted without modification. This view is still with us. There are those who would have us regard the Christian faith—in the sense of a body of doctrine—as something to be "received" and handed on unchanged.

On this view our function is priestly—the prophet has no place. Theology is the one subject in which there are no new discoveries to be made. Now my dissent from this view is based first of all on the fact that it seems to me to make religious truth a static and therefore a dead thing. It seems to deny the doctrine of the Holy Spirit in any effective form. What our fathers were able to do under His guidance in formulating religious truth in their day we ought to be able to do again with the same guidance, and if religious truth is an organic thing we shall have to make the attempt. In the second place the static view leads to an exaggerated respect for authority. The truth in the form in which it comes to us is unfamiliar. We have difficulty in making it our own and we accept it on authority and leave it at that. Now, authority is a good guide. Any body of truth which has been long and widely held and *acted upon* comes to us with strong claims upon our belief; but to leave it at that is to embark on the difficult and dangerous enterprise of life with second-hand beliefs, and we will fare better with a few simple convictions which we hold strongly because they are our own. There is the further difficulty that the static view puts an unbridgeable chasm between science and theology. "It is something of a shock to find that the restless progressiveness of science will not, in principle, allow it to conceive any truth as incorrigibly perfect and impels it for ever to improve and revise even its most certain doctrines. And if it is true, as most theologians have believed, that religious truth is essentially final, absolute and therefore unprogressive, there will arise at this point an irreconcilable divergence between science and religion." [1]

The emphasis on theological soundness has at times been so extreme as to merit the scathing satire which is called forth from Robert Burns.[2]

> "No! stretch a point to catch a plack;
> Abuse a brother to his back;
> Be to the poor like onie whunstane,
> And haud their noses to the grunstane,
> Ply every art o' legal thieving;
> No matter—stick to sound believing!"

Even to-day we are apt to magnify the virtue of belief, and the conditions of admission into the various branches of the Christian Church leave us with the impression that the indispensable condition of membership is an intellectual assent to a series of theological assertions. We must not make a virtue of credulity and a sin of doubt. There is no merit and no efficiency in persuading ourselves to assent to dogmas which we barely understand. Only the faith which, on its intellectual side, embodies an overmastering conviction will really sway our lives and save us, either in this world or the next. Not the faith which we hold, but the faith which grips us, is effective unto salvation, and it is through doubt that some of us at least come to this faith. Professor McDougall[1] boldly affirms that "Belief in the fullest sense of the word must be preceded by doubt, by the questioning attitude which issues in judgment." Francis Bacon[2] has assured us that "If a man begin with certainties he shall end with doubts, but if he be content to begin with doubts he shall end with certainties."

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[1] Schiller, *Problems of Belief*, p. 20.

[2] *A Dedication to Gavin Hamilton, Esq.*

To refuse to submit truth to scrutiny lest it should fail to meet the test is cowardice—not faith. Nor is any belief too sacred to be faced in this spirit. Schiller[3] rightly says: "Even more lamentable is apt to be the fate of a belief which well-meaning friends (or covert sceptics) try to exempt from the struggle for existence and rescue from the field of debate by pleading for it benefit of clergy. In many cases the belief which is made too sacred to be subjected to inquiry and becomes too proud to fight, simply evanesces. On the other hand perpetual exposure to attack and constant readiness to fight for its existence have singularly little power to hurt belief."

On the other hand there is a real danger in the cultivation of doubt as a permanent attitude of mind. It should have a positive function and should be aimed at sifting the true from the false and establishing the true. If there is a "will to believe" there is also a "will to doubt" and a

[1] *Outline of Psychology*, p. 364.

[2] *The Advancement of Learning.*

[3] *Problems of Belief*, p. 43.

"will to disbelieve," which are much more harmful. The fact that a belief seems to us to be desirable is no reason for concluding that it is untrue, although it ought to make us more careful in considering the evidence for it. But we are in much greater danger if we cultivate a habit of dallying with belief and glorify an attitude, more or less permanent and complete, of suspended judgment. To have convictions and act on them is the essence of successful living and the prerequisite of progress both in science and religion.

The main purpose of this little book is to investigate the structure and methods of natural science as they are revealed in physical science—to show that the methods differ less fundamentally from those of religious thought than is often supposed, and to make clear that the incompleteness of the account which science gives of the world is such that religion still preserves her right to make an essential contribution. Few more remarkable changes have taken place in the history of scientific thought than the movement of self-criticism, which, during the last fifty years, has revolutionised the scientific outlook and completely changed the relations of natural science with theology and philosophy. Formerly science was prepared to recognise some areas of experience as temporarily outside her scope; but religion was left rather in the position of King Canute, and the probability that the waves of advancing scientific discovery would show any permanent respect for the dry territory which she occupied was small. To-day, however, science seems prepared to recognise that even throughout the area which is specially her own her account must always from the very nature of her methods be incomplete. We shall therefore endeavour to follow the main outlines of this movement of thought and try to appreciate its bearing on the subject which is our immediate concern.

Chapter II

THE EMPIRICAL SCIENTIFIC LAW

In order that we may make a careful study of the scientific method in practice it will be necessary to consider its application to one or two simple cases. The scientist first selects the phenomena—the range of experience which he desires to investigate. This confers upon him an initial advantage. Thus, Campbell[1] says: "We have already had reason to suspect that because our object in selecting judgments of the external world for examination is that we may make laws from them, we refuse to include in our selection any judgments which will not fall neatly and satisfactorily into laws: we accomplish the apparently miraculous feat of reducing a chaotic world to order, because we carefully confine our attention and our efforts to those portions which we find can be ordered." This self-imposed limitation may only be temporary, but it is important to notice it.

We shall assume that our interest is for the moment centred in levers, and consider how Archimedes discovered the "Law of the Lever." If we take a bar, pivot it at the centre and hang on equal weights at the two ends we shall find that it balances. If we pivot it at a point two-thirds of the length from one end and one-third from the other weight, then a weight of two at the latter end will balance a weight of one at the former end. If we vary the suspended weights and the distances, always adjusting them until they balance, and record our observations, we shall get four columns of numbers. These will be sets of simultaneous measurements for E, L, *a* and *b* as shown in the diagram.

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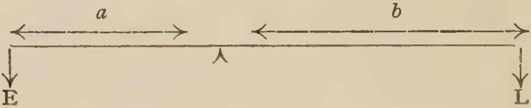
[1] *Elements of Physics*, p. 87.



If we use every available value for these four quantities we shall have a collection of data which gives a very complete account of the behaviour, in certain circumstances, of this particular bar. But there is nothing characteristically scientific about this collection of data. It is historical rather than scientific. If we repeat previous values we find that the result previously obtained holds good approximately, and we can, therefore, with an almost complete confidence, solve any problem for this particular bar. We can find approximately what weight suspended at a given distance will balance another given weight also at a given distance. So far, the law—that characteristic product of the scientific method—has not appeared. As we contemplate the data, however, we are sooner or later struck by a uniformity. Each set of simultaneous values is characterised by the fact that the value of the weight E multiplied by the value of the distance a, is equal to the product of the value of the weight L and the value of the distance b. In the form of an equation then $E \times a = L \times b$, and this, whether expressed in words or in symbols, is the law of the lever. The first remarkable thing about this law is its amazing economy of thought, and this is true of all scientific laws. Indeed, Mach[1] says that "Economy of apprehension and transmission is of the very essence of science." This little equation of four symbols summarises our whole collection of data. All our observations can now be dispensed with. By remembering this equation, or the law of which it is the shorthand expression, we can solve all the problems for this bar. How has this discovery been achieved? Now, although the process which Archimedes actually went through was probably similar to that indicated, the account which he gives us of the discovery is entirely different. There is no mention of experiments and no reference to real masses and real bars. To Archimedes, scientific laws were laws laid down for the behaviour of natural objects and discoverable *a priori*. They were laws of nature promulgated by some divine law-giver. As Poynting[2] says: "Even now these early stages in the history of thought can be traced by survivals in our language —survivals due to the ascription of moral qualities to matter. Thus gases are still sometimes said to obey or to disobey Boyle's Law, as if it were an enactment for their guidance, and as if it set forth an ideal, the perfect gas, for their imitation. We still hear language which seems to imply that real gases are wanting in perfection, in that they fail to observe the exact letter of the law. I suppose on this view we should have to say that hydrogen is nearest to perfection; but then we should have to regard it as righteous overmuch, a sort of Pharisee among gases which overshoots the mark in its endeavour to obey the law. Oxygen and nitrogen we may regard as good enough in the affairs of everyday life. But carbon dioxide and chlorine are poor sinners which yield to temptation and liquefy whenever circumstances press at all hardly on them.

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[1] *Science of Mechanics* (English Edition), p. 6.

[2] *Collected Scientific Papers*, p. 601.

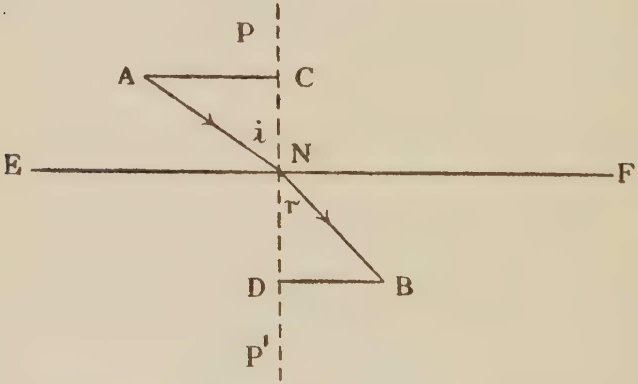
"There is a similar ascription of moral qualities when we judge bodies according to the fulfilment of the purpose for which we use them, when we describe them as good or bad radiators, good or bad insulators, as if it were a duty on their part to radiate well or insulate well, and as if these were failures on the part of Nature to come up to the proper standard. These are, of course, mere trivialities, but the reaction of language on thought is so subtle and far-reaching that, risking the accusation of pedantry, I would urge abolition of all picturesque terms. In our quantitative estimates let us be content with "high" or

" low," " great " or " small," and let us remember that there is no such thing as a failure to obey a physical law. " A broken law is merely a false description."

The modern rôle of the law of nature is thus a very much humbler one. It is a condensed summary of past experience carrying with it a promise also of future fulfilment. But it is *our* description, not something inherent in the phenomena themselves, and it is reached only by an investigation of the phenomena. This will become clear if we look again at the way in which Archimedes attempts to derive his law by *a priori* reasoning. He begins by asserting that equal weights suspended at equal distances from the fulcrum will balance. This assertion at first sight seems to require no experimental evidence at all—no familiarity with levers—no first-hand contact with phenomena. It seems an unchallengeable piece of *a priori* reasoning. But in the statement of this proposition what it omits is almost more remarkable than what it asserts. Our actual lever—the bar or whatever it is—has disappeared, and nothing remains but two weights and a length divided by the fulcrum. If one end of the lever is painted red and the other painted blue, will the proposition still hold ? Nothing is said about colour in the statement. And why should not the direction in which the lever points have some bearing on the problem ? Now Archimedes was perfectly right in ruling out these considerations. None of them is relevant. But he was entirely wrong in ruling them out *a priori*. No observer brought here from another planet and shown a rod with the two ends painted different colours would have felt entirely happy about Archimedes' statement unless he had some previous experience of painted rods, and could say from his experience that, for purposes of balancing, colour was immaterial. Only special experiments or common experience could have justified Archimedes. *A priori* he had no right to make the assertion. What he has done is to "abstract" from the actual concrete rod its size, shape, particular material, colour, orientation, etc., etc., and to make his assertion about an ideal rod possessing nothing but length and rigidity. This ideal rod is not a percept—*i.e.*, something which can be actually perceived. It is a concept—a symbol constructed by his mind. When we come to investigate scientific laws we find this an invariable characteristic. They are all concerned with concepts. Sometimes, as in this case, the concept is suggested by objects of perception, *e.g.*, a very thin light rod. Sometimes we use concepts, *e.g.*, the electron, to which nothing in our perceptual experience really corresponds. Since the day of Archimedes we have carried the process still further. The suspended weights have disappeared and been replaced by forces—another concept. One of these symbolises the force applied by the active agent who is using the lever, and is called the "Effort" E, the other symbolises the resistance to be overcome or weight to be lifted, and is called the " Load " L. The product of the force into the perpendicular distance from the fulcrum is called its " moment," and the Law of the Lever now becomes the Law of Moments—*i.e.*, for equilibrium the two moments must be equal and in opposite directions.

Now it is precisely this formation of concepts which gives the scientific method its power. It amounts to the possibility of classing together, for specific purposes, very diverse phenomena and apparatus. For instance, anyone who opens an elementary text-book of experimental mechanics will find in the chapter dealing with the lever a list of levers, including the crow-bar, kitchen poker, human forearm, oar, sugar-tongs, scissors, etc., etc. This diversity of articles suggests the story of the old lady who travelled with her pets and presented the ticket-clerk with a problem which he had to refer to the station-master. The judgment of that worthy was delivered by his subordinate as follows: " Station-master says, mum, as cats is dogs, and rabbits is dogs and so is parrots, but this 'ere tortoise is a hinsect, so there ain't no charge for it." For the purpose of the railway company the concept dog included cats, rabbits and parrots. For the purposes of mechanics all the articles in the preceding list may be treated as levers. They come within the concept, and the Law of Moments enables us to deal with them all. The data of our experience become manageable, coherent and intelligible, and by assuming that they will continue to act in the future as they have always been found to do in the past, we have a power of prediction which is of the very first importance for the business of actual living.

Let us take another simple case. When a beam of light, AN, travelling in air, strikes a water surface EF (or the surface of a block of glass), it is bent from its path in a way illustrated in the accompanying diagram.



If we draw the perpendicular PNP′ to the surface we can measure the two angles *i* and *r*, known respectively as the angles of incidence and refraction. For the case of water these angles were actually measured by Ptolemy (323-285 B.C.). He varied the angle *i* and measured the corresponding angle *r*, tabulating his angles in pairs. Now this may not seem a very useful or important exercise of skill, but the corresponding measurements for glass are of very great practical importance indeed. The whole art of lens making and the design of optical instruments depends on it. But the construction of a table of corresponding values of i and r and the use of such a table would be a very cumbersome affair. Yet no simple relation—no law—connecting i and r could be discovered until 2000 years after Ptolemy's time. The difficulty is that there is no logical, fool-proof method of deducing a law from the data. The law is always an *induction* not a *deduction.* It is suggested by the data and must co-ordinate and fit the data, but it is never dictated by the data. In the case under consideration the generally-accepted law was discovered by Snell in 1621. He found that if equal distances NA, NB were measured along the two paths, and the perpendiculars AC, BD drawn to the normal PNP′, then, for all values of the angles the ratio of AC to BD was constant or, in mathematical language, the ratio of the sines of the angles was constant. This law we can put in more abstract language still, in the form

$$\frac{\text{Sin } i}{\text{Sin } r} = \mu \text{ or Sin } i = \mu \text{ Sin } r.$$

Here again we see the amazing economy of thought. In this minute algebraic equation we have, condensed and available for transmission, all the information contained in Ptolemy's table and more! since, if we know the constant denoted by μ, we can calculate the angle of refraction for *any possible* value of the angle of incidence.

On pursuing our investigations we find that for every transparent substance the same simple law holds, the only difference being that for each different substance we have to substitute a different value for the constant μ. As before, we are dealing with concepts. The surface is an ideal plane—all the irregularities of an actual surface are "abstracted." The beam of light has become a single "ray," represented in the diagram by a line, although all efforts even to obtain a very narrow beam of light have so far failed in practice.

For our third illustration let us take a case of a slightly different kind. The two previous illustrations have shown us laws relating to data resulting from experiment—*i.e.*, observation in artificially controlled circumstances. The experimenters were able to vary the conditions at will and exclude all irrelevant and disturbing conditions. We shall now consider a case where the data are the result of observation in conditions where no control is possible. In the sixteenth century there lived a Danish astronomer called Tycho Brahe who, for the accuracy and design of his observing telescopes, was unsurpassed in his own time and for long afterwards.

His main contribution to science was an elaborate, careful and accurate set of observations giving the position of the planet Mars in the heavens at various times. Like the results of experiments on a lever, or Ptolemy's table, this mass of data was not science, but it was the raw material, for, as we have seen, nothing can be done towards discovering laws of nature until we have a record of perceptual experience to start from. So far the data were all unrelated, incoherent and meaningless. Tycho himself was unable to carry the work any further. He was the observer, *par excellence*, but he did not have the special genius required for "discovery." The next part of the work was accomplished by Kepler. Obviously, if he could find a path in space upon which lay all the positions of Mars given by Tycho's table, then this would be the path of Mars, and all the data would at once be simplified, related and made coherent. But this path could not be *deduced* from the data. It could only be reached by induction, and this requires fertility of imagination and some kind of gift of intuition. Kepler's early efforts were unsuccessful, but he finally hit upon the idea of an ellipse with the sun in one focus. It is difficult for us to realise the bold and revolutionary nature of this suggestion as it must have appeared to Kepler and to his contemporaries. His mental history in making the discovery is pretty accurately known and is a very interesting study. His progress was restrained and delayed by the dead hand of authority and the *a priori* conception of natural law. It was implicitly believed in his time that the planets, being heavenly bodies, must move in perfect curves, and, as the circle was the only perfect curve, it was not fitting that their orbits should be other than circular. Further, the cause of their motion—namely God—being constant, it was assumed as obvious that their velocity must also be constant. Astronomers soon discovered that the observed motions of the planets could not be reconciled with this dogma in its naïve form. The dogma, however, must be retained, and so they hit upon the happy expedient of making the planet describe a small circle, the centre of which was carried round a larger circle, whose centre was the earth. On this hypothesis the following witty comment has been made:[1] "The planet's motion is obtained by circular motions, it is true, but it is not itself a circular motion with reference to the earth as centre. The astronomers have entered on a slippery path. We view them with the same suspicion with which we watch a Broad Churchman expounding the Thirty-Nine Articles."

Even so, the correspondence between theory and observation was not nearly close enough. A third circle was added, and it was further admitted that the large circle was eccentric with respect to the earth, and the smaller ones with respect to their supposed former centres.

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[1] Sullivan, *Aspects of Science*, p. 60.

Sullivan[1] continues: "The rise of the 'higher criticism' of this system leads to the history of modern astronomy. It is to be noted, however, that the first higher critic, like the first higher critics in other departments, was not wholly emancipated from his early teaching. Copernicus effected the immense revolution of placing the sun in the centre of the system, but he did not abandon circular motion. So he had to retain part of the epicyclic apparatus. The revolution was first completely effected by Kepler, but even he conducted his early researches as a semi-believer, a kind of very Broad Churchman. He made nineteen successive attempts to explain the motion of Mars by the arrangements of eccentric and epicyclic motions, and only then did he frankly throw the great principle of circular motion overboard and state that the actual paths of the planets were ellipses."

This idea once grasped, all the observations fell into place and the discovery was made. Kepler's discovery makes clearer than ever the nature of the process of induction. It is a sort of inspired guessing. Truth seems suddenly to flash across the inquirer immersed in his research. He becomes aware of something of which a moment before he was not aware. He has not arrived at his discovery by any series of necessary steps; no rules can be given for the process; the idea has dawned upon him. He proceeds to put the intuition and its consequences to the test, and the discovery is made. Great scientific discoverers are men who appear to have a "genius for the intuitive perception of the hitherto unknown." Kepler's law (with two others subsequently formulated) was extended to the other planets and in its more general form may be stated as follows: "It is a property of planets to describe ellipses with the sun in one focus." Let us note once more the process of idealisation. All the planets are treated as points—their mass, shape, chemical composition, temperature, rotation, etc., are all abstracted, and they become mere points. The same thing happens to the sun. And the very idea of motion is a concept. We never perceive motion. On this point Hobson[1] says: "The individual positions of Mars, which Kepler took as a basis, following the observations of Tycho Brahe, do not in themselves alone contain the thought of the orbit of Mars; and all heaping up of particular positions could not lead to this thought, if there were not active from the beginning ideal presuppositions through which the gaps of actual perception are supplemented. What sensation offers is and remains a plurality of luminous points in the heavens; it is only the pure mathematical concept of the ellipse, which has to have been previously conceived, which transforms this discrete aggregate into a continuous system."

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[1] Loc. cit.

These three laws which we have so far discussed are typical of the so-called "empirical" laws of science. They assert a constant relation, usually most easily expressed in mathematical formulæ, between concepts. They make no attempt to *explain* the phenomena with which they deal. They do not even pretend to answer the question "Why"? They do not hint at any rational connection between the concepts. If we ask "Why should planets move in ellipses?" Kepler's law is silent. It is hardly possible to say of these empirical laws that they are either true or false. They are simply more or less accurate summaries of our experience. As our methods of measurement improve and our range of experiment extends, they may have to be amended or modified. But at the worst they can never be shown to be anything but imperfect and inadequate. They do not pretend to explain, and therefore their explanation can never be wrong; they do not claim to reveal any relationships between quantities other than a purely mathematical relationship, and if the accuracy of this has ceased to satisfy us, it will be because we demand greater accuracy, not because there is any change in the accuracy with which the law "fits the facts."

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[1] *The Domain of Natural Science*, p. 118.

Thus the statement of the empirical law is the first step in the organisation of scientific knowledge. We are face to face with an amazing diversity and multiplicity of phenomena constituting our physical environment. If we are to live intelligently we must organise our past experience so as to make it readily available for meeting the circumstances of the moment and providing for the needs of the future. In the earlier stages the results of past experience are accumulated instinctively as an unorganised background in our minds. Later we become conscious of the need for organisation, and science is the response to this very practical need. Yet science is always more than this. It is a method of self-expression, a kind of creative activity, which in its higher flights is just as personal and as individual as music or painting. This activity is obvious in the earliest stages of the " discovery " of laws. Physical objects have to be arranged in classes in accordance with observed similarities, and this means choosing the particular similarity which is significant for the purpose in hand—*e.g.*, for different types of lever. The next step is the formation of abstractions or concepts, suggested by our perceptions, but different from any of them and representing the common feature or group of features which is regarded as alone relevant for the purpose of classification. The law refers in the first instance to a selected range of phenomena chosen for investigation. It is then extended to similar phenomena in conditions not in all respects identical, and if this extension is justified by experience the power of prediction thus shown generally suffices to establish its claim to the title law. It is important to remember, however, that the law is not inherent in the world of percepts or " things." It is a creation of the mind, the value of which is tested by its applicability to percepts or perceptual happenings. "Indeed Natural Science need not go beyond the recognition of this element of fact: it is unnecessary for its purpose to make the assumption that a single law has a precise correspondence with a single definite set of relations which actually subsist in nature. Still less is it necessary, for the purposes of Natural Science, to assume that the law corresponds to a set of relations between real entities. The formation of precise views on these matters is the task of philosophers; the man of science need not go beyond the superficial view which contents itself with the recognition of the essential element of fact in the world of percepts."[1]

This then is the first step in the building-up of a symbolic representation of experience. The concepts are our symbols. The laws are their relationships. We seem to have embarked on a very different venture from that popularly attributed to Natural Science.

[1] Hobson, *The Domain of Natural Science*, p. 26.

Chapter III

PHYSICAL THEORIES

The next step in the organisation of scientific knowledge is the discovery of the theory or hypothesis. The theory bears to the empirical laws the same kind of relation as these laws bear to the data of sense perception. The results of observation (*e.g.*, Tycho's tables for the motion of Mars, or Ptolemy's table of refraction of light passing from air to water) remain disconnected, incoherent, unrelated, meaningless, until the scientist is able to approach them with the law in his mind. The law is the idea which orders them. It supplies a logical relation. Each observation is no longer an isolated fact; it becomes part of an organised whole. The data can all be deduced from the law and further data not contained in the table can be predicted. So when we take the next step and discover a theory or hypothesis, we are endeavouring to relate and connect laws. They are the data from which we start. They are unrelated and in a sense unintelligible. The theory co-ordinates and gives the meaning. From it we can deduce the laws already known, and from it also we can predict laws hitherto undiscovered. It is even harder to lay down any suggestions for the discoveries of theories than for the discovery of laws.

The method of trial and error, possible in the case of the simpler empirical laws, seems quite inapplicable here.

Not only can theories never be deduced from the laws, but it is doubtful whether they are reached by a mental process which can fitly be called discovery. They seem rather to be creations, akin to the creations of art—efforts of the imagination. Of course they are not acts of pure imagination. They are suggested by the relevant facts—by the laws which are to be summarised. Not only is it impossible to frame a reasonable hypothesis or theory without reference to laws—it is impossible to frame any kind of hypothesis or theory at all. The theory must start from somewhere. But the more one thinks about the outstanding general theories of science and the method of their discovery, the less important does the part played by any logical process seem to be. The discoverer has used imagination, insight and intuition. The discovery is like a light breaking, a brain-wave, and if religiously-minded people like to call it a revelation or an inspiration it is difficult for the scientific mind to forbid. It has been said of Clerk Maxwell that "Even as a purely scientific man, his rational faculty, as evidenced by his mathematical reasoning, was a distinctly more fallible thing than his intuition."[1] It is characteristic of Maxwell that even when his proofs were faulty, his results were usually sound.

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[1] Sullivan, *Aspects of Science*, p. 43.

Let us take as an example of a great discovery the work of Sir Isaac Newton on gravitation. His data consisted in the main of Kepler's Laws of planetary motion and Galileo's law of the acceleration of a falling body. We shall not attempt to follow the workings of his mind, we shall not even attempt to weigh the evidence for the authenticity of the falling apple, but in the end he produced, discovered, or invented his Law of Universal Gravitation. It is called a law, although, as we shall see, it is in some respects more akin to the theory than to the empirical law. His law is usually stated as "Every particle of matter in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them." In symbols, if F is the value of the force between two particles, m_1, m_2 their masses, and r the distance between them, then

$$F = G\frac{m_1 m_2}{r^2}$$

where G is a constant known as the Gravitational Constant. From this simple statement Kepler's three laws can be deduced mathematically; tides can be calculated and the movements of the heavenly bodies predicted with extraordinary accuracy. It is commonly said that the verification of the law is the *Nautical Almanac*. This Almanac, which is published several years in advance, contains tables based on this law of Newton's, making it possible to calculate the positions of the principal stars at any moment throughout the year. If an observer wishes to look at a star through a large telescope the procedure is somewhat as follows: He looks at his clock and decides on a convenient instant for the observation. He then refers to the *Nautical Almanac*, makes one or two short calculations, sets two circles (fixing the direction of the telescope) in accordance with his calculations and waits for the agreed instant. At precisely the instant chosen for the calculation the star will, if the calculations have been accurately made, move into the field of view of the telescope. It has been said that " The undevout astronomer is mad." Certainly the observer who can go through this common routine for the first time without being almost awed at the intellectual achievement which has made it possible is lacking in all sense of proportion.

Something in the nature of a *Nautical Almanac* was possible, however, without Newton's Law. A more specific " verification " of Newton's Law comes from the discovery of the planet Neptune. A small irregularity in the observed motion of the planet Uranus led the Cambridge astronomer Adams to suspect that the proximity of a hitherto undiscovered planet was responsible for this irregularity. Newton's Law enabled him to predict its exact position—predicted independently by the French astronomer Leverrier—and when the telescopes were turned on the spot in the heavens which he indicated the new planet swam into human ken.

Now this law is akin to the empirical laws discussed in the preceding chapter.

The law of the lever described how actual levers had been found to work under certain forces applied at certain distances. The law of refraction described how a beam of light had been found to behave when incident on a transparent surface. Kepler's law described the path of a planet with reference to the sun. In each case the description was achieved by asserting some relation of concepts. Now Newton's law describes the path of a planet in a more symbolic and general form, but it includes vastly more in its sweep. The falling apple, the tides, the clock-pendulum, the water on the hillside all come within its scope. Obviously we are again dealing with concepts, with particles of matter and force. The composition of a piece of matter, its shape, its size, its temperature, all disappear, and there remains nothing but a point in space with a number attached representing what Newton called its mass—the number appropriate for insertion in the equation given above (p. 40). But there is an important feature about the law which marks it off from those considered in the previous chapter. It not only describes, but it suggests an explanation. Kepler's law, in effect, says: "Planets describe ellipses with the sun in one focus because that is the property of planets." Newton's law says: "Planets describe ellipses with the sun in one focus because there is a force of attraction between the particles of the planet and the particles of the sun, which force is calculable according to the following formula." The descriptive element of the law is left in full possession of the field if we say that heavy bodies in the universe behave *as if* there were a force, etc. Now this part of the law is of permanent value. It will presumably always enable us to calculate the positions of the heavenly bodies to a close degree of accuracy. The second element —the explanatory—is of much more doubtful value. Obviously it is a response to the demand of the human mind for an answer to the question "Why?" The descriptive element of the law sufficiently answers the question "How?" When the question "Why" is answered with "because there is a force," the mind is temporarily satisfied. To the man in the street, anxious to know why a stone falls to the ground, the reply, "because it is attracted by the force of gravitation" is, for the time being, satisfactory.

But it is to be noted that replies of this nature merely suggest new questions. "Why does every particle of matter attract every other particle?" "Why, in particular, does it do it according to this particular kind of algebraic relation?" No answer is forthcoming. We can only say that such is the property of particles of matter. In short, in the search for full explanation, for reality, science is involved in an indefinite regress, in which the explanation obtained at each stage is itself in need of explanation and this without end.

Moreover, this explanatory attempt of the theory adds nothing to its usefulness. If we regard the gravitational force of attraction as a mere scientific fiction, then Newton's Law becomes purely descriptive, and its value is unchanged. A rival method of describing gravitational phenomena has, of course, arisen in our own time in the theory of relativity. This theory makes any kind of force quite superfluous—in a word, it completely supersedes the explanatory aspect of Newton's Law, while leaving its descriptive aspect unchanged, as " true " as ever it was and as useful. By assuming the existence of the force we can calculate the flight of a ball, whether the force has any real existence or not.

This survival of the descriptive element is noted by Duhem.[1] " When the progress of experimental physics renders a theory inadequate, when the theory has to be modified and transformed, that part of the theory which is purely descriptive is embodied in the new theory almost complete, bringing with it as heritage all that was most precious in the old theory, while the explanatory part falls away to give place to another explanation."

We may take another example, the Wave-

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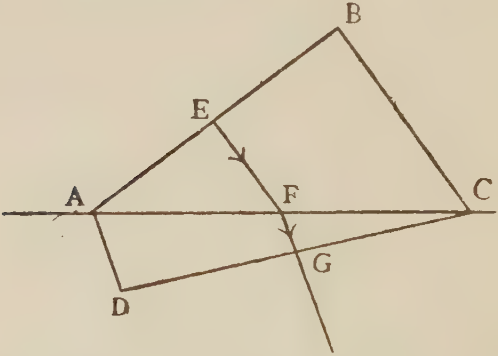
[1] *Théorie de la Physique*, p. 43.

Theory of Light. The propagation of light was for many years the battle-ground between two rival theories. One school of thought, supported by Newton, held that light consisted of tiny corpuscles shot off by the source of light and reaching our eyes directly or after reflection from illuminated surfaces. The other school, supported by Huyghens, held that light consisted in the propagation of a wave-like disturbance in a medium. We shall not follow in detail the history of the controversy. In the early years of the nineteenth century the wave-theory was fairly well established in popularity through the discovery by Young of the phenomenon of " interference " of light, and by Fresnel of the phenomenon of " diffraction." The former showed that two pencils of light could be combined to produce darkness. The latter showed that in passing the edge of an obstacle, or through an aperture in a screen, a light beam suffered diffraction or bending. These two phenomena are obviously much easier to " explain " if light consists of waves. But it was felt that an *experimentum crucis* was required to decide between the two rival theories, and an experiment of the kind seemed to be available. It was supplied by the phenomenon of refraction which we have already discussed. A ray of light on the corpuscular-theory will be the path of a corpuscle : on the wave-theory it will be the path of a small portion of the wave. Consider a wave AB approaching the plane surface AC of a transparent medium in which it travels at a lower speed. The end of the wave A is the first to reach the new medium. As B is still moving in the first medium that end of the wave must



swing round and when B has reached the surface at C, A will have moved to D, a distance less than BC. The path of a part of the wave E will be EFG, showing refraction at F. How is refraction to be explained on the corpuscular-theory ? Suppose that as the corpuscle approaches the surface it is acted on by a force of attraction perpendicular to the surface. Then, if we regard the velocity of the corpuscle as made up of two components, one parallel to the surface and one perpendicular to it, we can see that the force will not change the component of the velocity parallel to the surface, but will increase the component perpendicular to the surface. The path of the corpuscle will be the refracted ray EFG as before, but this time, one component of its velocity being unchanged and the other increased, it goes off in the second medium with a *greater* velocity than it had in the first. If then we can test the velocity of light in air and in water we have an *experimentum crucis* which will decide infallibly between the two rival theories and establish one on a firm basis of unassailable logical argument. So most people thought. The day came when the test was experimentally achieved. It was found that light travelled more slowly in water than in air, and the wave-theory was hailed as the victor. Many text-books still quote this experiment as decisive. It may reasonably be asked, however, whether the decision would have been so enthusiastically accepted if the wave-theory had not already shown itself superior to the corpuscular-theory in the simplicity and power with which it ordered, related and made intelligible all the diverse phenomena of light. For suppose the supporters of the corpuscular-theory were still convinced that their view was the "true" one, it would have been quite open for them to argue thus: "We interpreted the phenomenon of refraction wrongly. What really happens is that when the corpuscle reaches the surface of the water, or other medium, the component of its velocity parallel to the surface is diminished by action of a frictional kind. The component of its velocity perpendicular to the surface remains unchanged. The velocity in the water is therefore less than in the air. It was not our theory, but our application of it to this particular problem which was in error. On this new interpretation we are in agreement with your crucial experiment, which therefore fails to decide!" I doubt whether any crucial experiment which was ever devised really settled anything. Most of them are open to challenge of this kind and if they were not challenged it was because the successful rival was preferred on other grounds. It is interesting to note in passing that another crucial experiment was devised for the particular theories we are considering. It was proposed to attempt to detect a pressure on a surface exposed to light. If light consisted of a stream of small particles it ought to exert a pressure on the surface which received it, but if it consisted of waves, no such pressure was to be expected. So it was argued, and the experiment was tried, with no result. The evidence was therefore rather in favour of the wave-theory, although the result, being null, was inconclusive. The pressure due to the impact of the particles might be too small to be detected. We now know that such a pressure does indeed exist, although fortunately it was not discovered until we had seen that it was to be expected on the wave-theory as well!

Now the wave-theory of light may be regarded from the same points of view as Newton's Law of Gravitation. An imaginary wave-motion in a fictitious medium becomes the starting-point for mathematical analysis, and almost all the known phenomena of light and colour can be grouped, related and made intelligible. Snell's Law and many others can be deduced. The wave-theory of light is a great induction. It orders our experience and makes it possible for us to control it. It is unnecessary for us to postulate a "real" ether or a "real" disturbance. To quote Duhem[1] again: "The physicist, who sees in every theory an explanation, is convinced that in the luminous vibration he has seized the most intimate depths of the quality which manifests itself to us as light and colour; he believes in a substance, the ether, the various parts of which are animated by this vibration consisting of a rapid to and fro motion. We by no means share these illusions. When, in the course of optical theory, we still speak of luminous vibration, we no longer think of a true to and fro motion of a real substance; we think only of an abstract magnitude, a pure geometrical expression whose length, periodically varying, enables us to enumerate the hypotheses of optics, to rediscover by regular calculations the experimental laws which regulate optics. This vibration is for us a *representation* and not an *explanation*." If we wish to treat it as more than a representation the effort to regard the ether as a real substance compels us to confer upon it the most extraordinary collection of attributes and properties. As an explanation, the Wave-Theory of Light is a will-o'-the-wisp; as a conventional representation of the phenomena and their relationships, its beauty and usefulness cannot be gainsaid.

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[1] *Théorie de la Physique*, p. 34.

As a third example we shall take the dynamical theory of gases. The behaviour of gases has been summed up in a variety of empirical laws familiar to the student of elementary physics as Boyle's Law, Charles' Law, Graham's Law, Gay Lussac's Law, etc. We may rest satisfied with these laws or we may try to do for them what Newton did for the laws of Kepler—introduce some great simplifying idea from which as starting-point they can all be deduced. In the theory of gases there was, to begin with, nothing to suggest what form that idea should take. The selection of the analogy of a swarm of elastic particles in rapid motion was made by no chain of reasoning. Like the other theories it was an idea to be applied to the laws and tested by its agreement with them—not an idea derived from them. But it is a starting-point from which by deductive reasoning the laws can be reached, and it is an interesting fact that we tend to test laws by theories rather than theories by laws. So great is the value of relationship to our mind that an isolated law based on unimpeachable experimental observations is held with less conviction than one with slighter experimental foundation, but fitting into its place in the scheme of some great theory. In the case of the dynamical theory of gases we find the same option open to us as was presented by the other theories. We may either say gases behave as if they consisted of a swarm of elastic particles, in which case our theory is symbolic and descriptive; or we may say gases consist of a swarm of elastic particles, in which case we are trying to be explanatory and are making an assertion which is unnecessary and can never be verified. On this view a physical theory is not an explanation; it is a symbolical representation summarising as simply, as completely and as exactly as possible some group of experimental laws. The symbols used have no necessary connection with the phenomena they are used to describe and relate. At the same time, the more simply the theory orders our experience and the more fruitful it is in prediction, the more strongly we become convinced that the relations between the symbols of our theory *correspond* to real relationships in the phenomenal world.

CHAPTER IV

CRITICISM OF SCIENTIFIC METHOD

IN this chapter we shall criticise the method of science from the point of view of one claim only — the claim made *for* it, although not often *by* it, that its treatment of reality is exhaustive, and that the knowledge it gives us is the only knowledge which merits consideration. It would be ridiculous to criticise the method of science with a view to suggesting that it was inadequate for the special purpose of science. The success of the method is writ large wherever we turn. The contention of this book is that the purpose is achieved by using a highly abstract and specialised method, and that where there is a conflict between what appears to us to be scientific truth and something which also claims to be truth, although reached by another method, then both claims merit careful investigation.

First of all we must remember that the human mind is active throughout the whole process. It is emphatically not true that the percepts with which we begin are received by an inactive mind which on contemplating them has some truth as to their real nature dictated to it. The mind does not merely receive—it interprets—

I thought I saw a banker's clerk alighting from
    a bus,
I looked again and saw it was a hippopotamus.

When we say that we perceive something, we rather imply that we are not thinking, but the analysis of perception reveals the presence of thought. "Perception," says Collingwood,[1] "is explicitly immediate, but it always contains within itself mediation (thought, interpretation of sense data, inference from the immediately given or whatever one likes to call it) and is therefore never abstract immediacy."

Also the action of the mind is highly selective. A number of observers looking at the same prospect and therefore all having presumably the same kind of images formed on their retina will all see different things according to their tastes, education and interests. External reality comes to us as a continuous flowing stream of sense impressions. The percepts with which science deals are samples, selected, interpreted and removed from their context.

Next, the percept is used to form the concept—that distinctively mental product. Sir Napier Shaw says: "When we look back at the triumphs of calculation of the historic past we find always that the skilful calculator has substituted an ideal, upon which it is possible to operate, for the intractable reality. The late Lord Rayleigh made the general position clear in his first volume on Sound, where he pointed out that in order to study sound as vibration we imagine the sounding body to be completely isolated, though if it were so, there would be no sound."[1] This substitution of the ideal and conceptual for the real and perceptual is a commonplace of the physical laboratory. Let us assume that we have been set to determine the elastic properties of a brass wire. With a screw-gauge we set to work to measure the diameter of the wire. In order to eliminate errors due to irregularity of the wire we make this measurement in a number of places, taking perhaps as many as ten readings. We shall find divergences which are partly due to other causes, but in part at least are due to actual differences in cross-section from point to point along the wire. Now if we were interested in the particular wire under observation we should attempt to collect a large number of observations, and should set them out in such a way as to show the minute variations, in cross-section, of this particular wire from point to point along its length. This would give us a fairly complete account of this wire, which would be completely useless for the real purpose of science. What we are interested in, as scientists, is the behaviour of an ideal wire, to which this and many other actual wires will approximate so closely in behaviour that their peculiarities may be disregarded *for this particular purpose.* What we do, therefore, is to take the mean of our observations and treat this as the diameter of the wire. It may not be the exact value of the diameter at any particular point, but it is the diameter of our concept—a perfectly uniform wire in terms of which we interpret the experiments on the stretching of the actual wire which we proceed to perform. All the time we are at work in the laboratory we are translating percepts into concepts. The height of one mercury column we read off and call it temperature. Another mercury column we read and insert the result in a column headed pressure, and so on. The very instruments we use are on the table perceptual, and in our minds conceptual. Our actual tangent galvanometer is a coil of wire of considerable breadth and depth surrounding a magnetic needle of a certain magnitude and form which works on a pivot by no means smooth! The conceptual galvanometer in terms of which we state our results consists of a strictly geometrical circle without breadth or thickness and an infinitesimal horizontal magnetic axis which we can move in a horizontal plane without friction. In fact—as Professor Hobson reminds us—accurate measurement belongs to the conceptual domain. Now this method of the concept proceeds by deliberately disregarding individuality; it regards the differences between individuals as non-essential and irrelevant to its purpose—and for the purposes of science and at the level at which the physical sciences work individuality *is* relatively unimportant. We may disregard all that is characteristic, unique and individual about a brass wire with safety for most purposes. But is this true higher up the scale of being ? Does individuality not become more and more important, and with human beings is it not just the things which are characteristic and unique which are the most significant of all ? You can still form your concept " man," and for many purposes it will be sufficient. You can calculate how many people a theatre will seat, how many passengers a boat can safely carry, by using a conceptual man of assigned dimensions and mass. But if it is a matter of writing plays instead of occupying a seat in the audience, or sailing a boat instead of being a mere passenger, then the conceptual man is not of much use. We have to deal with the concrete individuals.

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[1] *Speculum Mentis*, p. 205.

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[1] *Nature*, December 9, 1922, p. 765.

It was asserted in the last chapter that science was " descriptive " and not " explanatory." We must now consider the meaning of these terms a little more closely. To the popular mind an event is explained most satisfactorily if it is traceable to an active agent. Early scientific explanations were of this type and the habit of mind is still with us. We can easily use Newton's Law of Gravitation in such a way as to imply that the force of attraction is an active agent which causes the mutual acceleration of the planets. It is now universally agreed that physical science knows nothing of efficient causation of this type. If this is a necessary element in explanation then physical science explains nothing. There is another sense, however, in which cause may be used and when the conditions are satisfied a type of explanation is achieved. Mill says: "To certain facts certain facts do, and, as we believe, always will succeed. The invariable antecedent is called the cause; the invariable consequent the effect." It is difficult to limit the terms cause and effect quite strictly in our thought to this definition, and the persistence of the idea of active agency may be made clear by examining a particular case where the cause and effect are simultaneous. Ohm's Law in electricity states that electromotive force and current are directly proportional. They increase together and diminish together. When both increase, is the increase of electromotive force the cause of the increase of current or vice versa? We shall find, on considering the matter, that when we modify our apparatus so as to increase the current we regard this increased current as the "cause" of the increased electromotive force, whereas if we manipulate the apparatus so as to increase the electromotive force, we regard this as the cause of the increased current. In short, the connection with the active agent establishes which is the cause and which is effect. This makes it all the more important to remember that all that physical science establishes is a fixed relation, usually with a sequence in time.

As David Hume long ago pointed out: "When we look about us towards external objects and consider the operations of causes, we are never able in a single instance to discover any power or necessary connection; any quality which binds the effect to the cause and renders the one an infallible consequence of the other. We can only find that the one does actually in fact follow the other." In its most general scientific sense explanation merely means establishing relationship. When science has succeeded in bringing a hitherto unknown or hitherto isolated phenomenon or event into its proper place in the conceptual scheme it is explained in the scientific sense. It is in this sense and in this sense only that explanation is now admitted as a legitimate scientific activity. In particular, we must be on our guard against the process of explanation when it means correlation of the unfamiliar with the commonplace. The motion of the planets is not in reality one whit less mysterious because it is seen to be the falling apple on a large scale. It is only our familiarity with the falling apple which has bred contempt and deadened our minds to its wonder. Even more illusory is the explanation by analysis which consists in effect of taking the lower elements of the universe as the most significant and attempting to give some account of the higher elements, such as consciousness, in terms of them. The method of interpreting the complex in terms of the simple, as in all molecular and atomic theories, is logically tantamount to a reduction of the more to the less and therefore a denial of the very fact to be explained. Analysis is useful for description, but phenomena are only explained by studying them in and for themselves.

We must now pass on to consider how a theory comes to be established. There are two tests that a theory must pass before it can command general acceptance. It must be consistent with itself and it must be consistent with the data of experience. Now, obviously, these conditions are necessary for the truth of a theory. The question arises, are they sufficient as criteria? No sooner has this question suggested itself than we see at once that it is quite conceivable that two theories, or even any number of theories might satisfy these two conditions and yet be inconsistent with one another. Hobson[1] says: "A remarkable illustration of the fact that a valid conceptual scheme, adequate for the purposes of description for which it was devised, is not necessarily unique, is afforded by the fact that different conceptual schemes of Geometry have been constructed. These systems are all logically coherent; they are inconsistent with one another as regards their several postulations; and yet several of them are adequate, at least when suitably restricted, for the description of percepts." A way out of this apparent impasse is to add simplicity as a criterion. From among the various competing theories we shall choose that self-consistent one which describes the greatest range of phenomena and describes it in the simplest way. Now in point of fact it would appear that, not only in scientific thinking, but in ordinary thinking, this does actually carry us some way. Rightly or wrongly, it seems to influence us. The rotation of the earth on its axis once in twenty-four hours is only a hypothesis. But it is a hypothesis which is very widely and strongly held. I once chanced on a book by Sir George Airy,[1] in which one of the sections was headed " Proofs that the earth really (in italics) revolves." I opened the book at the chapter in question with much interest. The proofs would well repay the study of the psychologist and logician. The first proof began by citing the data of experience which any theory must account for—the apparent motion of stars, etc., from east to west. It went on to point out that there are two alternative theories. Either this apparent motion is a real one and the earth is at rest while all the heavenly bodies revolve round it, or else the apparent motion of the stars is due to a real motion of rotation of the earth. The gist of the proof is contained in the words : " Now is it more likely that this large frame of things is turning one way, or that this small earth is turning the other way ? " I fancy that if any of Sir George Airy's pupils had tried to prove the equality of the angles at the base of an isosceles triangle in these terms he would not have got full marks! The proof goes on to point out that the stars are known to be at different distances from the earth and yet in their apparent motion they preserve their relative positions constant. It continues: "If I am entering into the Ipswich river, and I see not only ships moving, but every church and warehouse, and the solid banks which connect them, moving past me, and if a friend at my elbow should say, 'You are not moving, but all these solid things, churches and houses and fixed objects and banks, are in motion,' I should consider him to be a madman. The argument is precisely the same as applied to the Heavens." Now about this first proof many things might be said. Obviously it is not of the nature of a logical demonstration. Perhaps we ought not to regret this. It is doubtful whether logical demonstrations really carry much weight except with the highly sophisticated. Also, for those who live in a time when some inkling of what the mystic word "relativity" stands for has probably reached even the man in the street, the analogy chosen to enforce the argument is less conclusive than it might formerly have been. Have we not heard of the student who, sitting in the L.M.S. express, looked up from his treatise on Relativity and, accosting the ticket-collector, said: " Excuse me, but does Rugby stop at this train ? "

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[1] *The Domain of Natural Science*, p. 130.

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[1] *Six Lectures in Astronomy*, p. 59.

On the other hand, we are bound to admit that the argument comes to our minds with compelling force. The idea that the earth is rotating is so much simpler that we are willing to believe and to affirm with conviction that some mysterious force holds us by the feet to a whirling ball which drags us round a circular path of anything up to 25,000 miles in a period of twenty-four hours.

The second proof is of even greater interest. Observation of the planet Jupiter shows that it revolves. " Jupiter is a large planet that turns on his axis, and why do not we turn ? "

Finally there is the shape of the earth, which is the shape it would have assumed if, originally molten, it has rotated as it cooled. True! but we could easily invent twenty other reasons for the shape of the earth. Even abandoning the word proof, it seems an exaggerated claim to say: " From all these considerations, then, put together in proper order, we infer, as a matter of positive certainty (however hard it may be for our minds to receive it), we infer as a matter of certainty that it is the earth which revolves."

The fiction of a mind convinced against its will by a logical demonstration, which is suggested by the parenthesis, tends to obscure the fact that the exact opposite is the case. Present the whole fact to the mind, and, proof or no proof, we seem driven to the conclusion. Why ? We find that we have three sets of observational data to deal with : (*a*) the apparent motion of the stars ; (*b*) the observed rotation of another planet ; (*c*) the shape of the earth. The idea or hypothesis of the rotation of the earth relates this data so simply, gives it such coherence, intelligibility and meaning that we are compelled to accept it as " true." Yet we must be careful. " To regard the earth as rotating round its axis," says Hobson,[1] " is convenient for the purposes of descriptive Astronomy, and it is also convenient for the purposes of the dynamical description of the motions of bodies in the solar system. But however convenient is the assertion that the earth rotates, it still remains a convention, although the opposite assertion would vastly complicate both the astronomical and the dynamical schemes which would then have to be employed." It is a matter of convenient description and easy calculation ! Consider the bitterness of the controversy between the Ptolemaic and Copernican systems of astronomy, the heresy hunts, the persecutions ; the threat to the very existence of religion which its defenders saw in the rise of the new heliocentric view. " So far, the whole change from the Ptolemaic to the Copernican system consisted, as we should now describe it, in recognition of the fact that the relative motions of the sun and planets are much simplified by describing them as they would appear to an observer in the sun, rather than to a terrestrial observer; that is by the adoption of a heliocentric description. It will be observed that, so far, the only change consisted in setting up a simpler description of one and the same set of facts. It was owing to the great work of Newton that the full importance of the change of descriptive scheme was made manifest; when the heliocentric description of the motions of the bodies of the solar system was seen to be consistent with a dynamical scheme of great formal simplicity: and one to which the geometric description did not lend itself."[1]

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[1] *The Domain of Natural Science*, p. 196.

Over and over again we find the same phenomenon in the history of physical science. What decides between rival theories is not a crucial experiment or a logical clash. It is the accuracy with which they represent the data, the range of data which they correlate and over and above these obvious and easily-understood criteria, this mysterious insistence on simplicity. In electricity the controversy between the one-fluid and two-fluid theories was decided along these lines, although we have since considerably modified our views. In the controversy between the wave-theory and the corpuscular-theory of light the same considerations were weighed, as we have already seen. In the case of Relativity Laue has said:[1] "A really experimental decision between the theory of Lorentz and the theory of relativity is indeed not to be gained, and that the former, in spite of this, has receded into the background, is chiefly due to the fact that, close as it comes to the theory of relativity, it still lacks the great, simple, universal principle, the possession of which lends the theory of relativity an imposing appearance." Now this insistence on simplicity would be quite intelligible if truth were a matter of convenience and science a utilitarian scheme. This indeed is pretty much what Mach makes it. To him science is *merely* the response to a practical need. We cannot deal with phenomena unless we can connect them in our minds and we cannot organise these connections for our own appreciation and for transmission to our successors unless we succeed in organising them simply. To him, then, it would seem that a scientific theory might rightly be said to be useful or convenient, but hardly in any intelligible sense "true." Few of us can, however, rest satisfied with this in our less sophisticated moments. Of these moments it has been said:[2] "Nobody who has any portion of the scientific spirit can fail to remember times when he has thrilled to a new discovery as if it were his own. He has greeted a new theory with the passionate exclamation, 'It must be true!' He has felt that its eternal value is beyond all reasoning, that it is to be defended, if need be, not by the cold-blooded methods of the laboratory or the processes of formal logic, but, like the honour of a friend, by simple affirmation and eloquent appeal."

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[1] *The Domain of Natural Science*, p. 13.

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[1] *Das Relativitätsprinzip*, p. 19. [2] Campbell, *Physics*, p, 228.

My own conviction is that we rightly value the simplicity, the beauty, the meaning of a theory or law. These qualities are characteristic of scientific truth as of other kinds of truth. We face, however, the surprising fact that in this most exact of the exact sciences we have no infallible criterion of truth and no infallibly true theories. We must even employ different and mutually inconsistent types of theory for different purposes. We use an atomic theory of matter to represent chemical combination and a continuous theory of matter in dealing with elastic problems. We use the wave-theory of light in dealing with the phenomena of interference and diffraction while we have recourse to the quantum theory in dealing with the phenomena of photo-electricity. What, then, is the truth to the scientist? It is not an easy question to answer. Some day he hopes that all the phenomena of past experience will be summarised in conceptual schemes called laws. These laws will be gathered up and bound together into a coherent whole by a system of theories forming one huge conceptual scheme. The final result is not an explanation of reality. Physical science gives us no real explanation of experimental laws: it never reveals to us what lies behind and beyond our perceptions; but the more perfect it becomes the more we are convinced that the logical order in which it arranges experimental laws is the reflection of an ontological order, and the more strongly we feel that the relations it establishes between the data of experience correspond to relations between the percepts. In the end we are presented with a conventional representation of reality—with a kind of map in which the blue trails only *represent* rivers and the green patches only *represent* woods and the black lines only *represent* railways, but which still enables us to find our way across country and gives us a very fair idea of the experiences through which we shall pass in doing so. At present our map is very incomplete and our difficulty is to be quite sure that the small areas which we think adequately mapped are mapped in a way which will fit in with the whole scheme when the map is complete. We cannot know this until the map *is* complete. The whole structure of physical theory is in this case, and the matter may be summed up[1] as follows: "Thus analysis of the methods by which physical theories have been built up demonstrates beyond all doubt that these theories cannot be put forward as an explanation of experimental laws; on the other hand an act of faith, which this analysis can neither justify nor restrain, gives us the assurance that these theories are not a purely artificial system but a natural classification. We can here apply that profound reflection of Pascal: "We have a powerlessness to prove which makes dogmatism impossible; we have a conviction of truth which no Pyrrhonism can undermine."

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[1] Duhem, *La Théorie Physique*, p. 36.

Chapter V

MIRACLES AND THE SUPERNATURAL

Before the rise of that organised common sense which preceded and later was absorbed into natural science very little was known of the "uniform sequences of nature." Man lived in a world where each event was separate, unrelated and unexplained. The unexpected was always happening, and each unrelated effect tended to be ascribed to an active personal cause. As knowledge of natural sequences became more and more extended, and as these sequences became distributed over ever larger tracts of experience the tendency to treat them as self-explanatory arose and took strong hold of the popular mind. This, as we have seen, was a misconception and it led in time to a still more serious one. The spectacle of a world where orderliness was more and more obvious, where the reign of law brought consistency to one mass of chaotic data after another, produced two entirely different kinds of impression on the minds which witnessed it. To Kepler it meant that God was the great Geometer and that he (Kepler) was thinking God's thoughts after Him. Newton's reaction was similar. In his *Principia*

(1686) he says: "This most beautiful system of the sun, planets and comets could only proceed from the counsel and dominion of an intelligent and powerful Being. All that diversity of natural things which we find suited to different times and places could arise from nothing but the ideas and will of a Being necessarily existing. And this much concerning God, to discourse of whom from the appearances of things does certainly belong to Natural Philosophy." With this attitude of mind contrast that of Laplace in his famous retort to the Emperor Napoleon I. In accepting a presentation copy of *La Mécanique Celeste*, the Emperor is reported to have said: "M. Laplace, they tell me you have written this great book on the system of the Universe and in it you have not once mentioned the name of its Creator." "Sire," replied Laplace, "I had no need of that hypothesis." Laplace may have meant by this that cause was no concern of his *qua* mathematician. In this view we should support him, and we are not surprised to-day if we find a book on mathematical astronomy by someone whom we know to be a devout Christian in which all mention of the Creator is omitted. The surprise of the Emperor and the reply of Laplace seem to indicate, however, that something more was involved. The implication is that an area of experience where God's presence and power were previously thought to be involved in a very direct and essential way was now able to get on without Him. What previously God alone could do was now quite satisfactorily performed by the force of gravitation. And this was typical of a widespread attitude of mind. God was pre-eminently revealed in the miracle, the unexpected, the unintelligible, the mysterious. Naturally this sphere became more and more restricted as Science progressed, and it looked as if before long " God would be conducted to the confines of His own Universe and bowed out." It is not surprising that religion looked upon science as a hostile force and regarded its triumphant progress with dismay.

Associated with this point of view and perhaps partly due to it was a general loss of emphasis on the self-revelation of God in the world of ordinary experience. He was thought of too much as standing outside a nearly self-sufficient universe in which He occasionally interfered for some special purpose. It is one of the positive contributions of science to religious thought that it drove the religious man to correct this one-sided view and opened his eyes to see the evidence of God's handiwork in the uniformity of nature itself, and a revelation of His mind and purpose in the familiar, the intelligible and the explained. This change of outlook is not, of course, universal among Christian people. We are perhaps past the stage of the man who, when lightning-conductors were first discovered, refused to have one placed on his house, saying that he would scorn to interpose a copper-rod between a guilty conscience and an offended God. Yet there are still many religious people who find God only in the mysterious and "inscrutable." If a man dies in his bed their verdict would be "natural causes": if he is struck by lightning, he dies by an "Act of God." This phrase still lingers in our legal phraseology to mark the old view. On one occasion a Norfolk canal burst its banks and flooded the adjoining fields, doing much damage. The farmers claimed and were awarded compensation. It was ruled, however, that had the canal banks been lined with blue clay, then the claim would not have stood, as the bursting of the banks could then have been claimed to be due to an Act of God! Bereavement on this view becomes a "visitation" and pestilence and famine a "judgment." It is undoubtedly people with this type of mind who even to-day find evolution such a stumbling-block. It is so "natural." It gives so little scope for the kind of action which testifies to them of the presence of God. They cling to the gap between the inorganic and the organic and defend it as the last ditch of their position. The orderly succession of species they are prepared to admit and to regard as "natural," but the creation of life is the prerogative of God, and the gap stands to attest the necessity of His presence. Now it would be ridiculous to assert that this gap seems at the moment to be in danger of disappearing, but to see the activity of God in the gaps and not in the process is severely to limit His range of action and greatly to impoverish our own religious thought. The uniformity of nature does not necessarily mean that this world is a great, self-sufficient machine. There is another interpretation which is equally legitimate and which was suggested by the Cambridge Platonist, Henry More.[1] "I affirm," he says, "with Descartes that nothing affects our senses but such variations of matter as are made by differences of motion, figure, position of parts, etc., but I dissent from him in this, that I hold it is not mere and pure mechanical motion that causes all these sensible modifications in matter, but that many times the immediate director thereof is the spirit of nature, one and the same everywhere, and acting always alike upon the like occasions, as a clear-minded man, and of a solid judgment, gives always the same verdict in the same circumstances." Thus, what to the scientist is the uniformity of nature may be to the religious man the trustworthiness of God. We shall be helped in right thinking if we remember the inadequacy of all scientific explanation and endeavour to recover that sense of the mystery of familiar things which is a very real part of the religious outlook and, incidentally, has been a notable characteristic of many of the greatest men of science.

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[1] *The Immortality of the Soul*, Book III. Chap. 13, par. 7.

This brings us naturally to a consideration of miracles, and in the discussion which follows my indebtedness to Dr Tennant will be obvious to all who have read his recent book,[1] although I am far from wishing to saddle him with responsibility for my interpretation of his position. As he there points out, the idea of the miracle has undergone evolution. Originally, *i.e.*, in the Old and New Testaments—miracles were merely "signs" of God's presence and power. They were events of an unusual and striking character, but as the idea of natural law had not then arisen, the miracles could not be regarded as breaches or suspensions of these laws. It was on this ground, however, that the pseudo-scientific attack on miracles was delivered in the nineteenth century. The attack involved, as we can now see, a complete misconception, namely, that an unexplained event necessarily meant the breach of a law which admitted of no exceptions. The broken law is, as Poynting has said, merely the inadequate description, and how can we say of any event that it will *always* refuse to be scientifically explained by being included in some more adequate description? Of laws which admit of no exceptions in the past, science may know something, but of laws which admit of no future exceptions it knows nothing. Hence the absurdity of asserting dogmatically what is or is not possible in the way of ordinary natural events—

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[1] *Miracles.*

an absurdity at which Kingsley pokes the most delightful fun in the *Water-Babies:*

> "And no one has a right to say that no water-babies exist till they have seen no water-babies existing! which is quite a different thing, mind, from not seeing water-babies; and a thing which nobody ever did, or perhaps ever will do. . . . But a water-baby is contrary to nature. Well, but, my dear little man, you must learn to talk about such things, when you grow older, in a very different way from that. You must not talk about 'ain't' and 'can't' when you speak of this great world around you, of which the wisest man knows only the very smallest corner, and is, as the great Sir Isaac Newton said, only a child picking up pebbles on the shore of a boundless ocean. You must not say that this cannot be or that that is contrary to nature. You do not know what Nature is, or what she can do; and nobody knows; not even Sir Roderick Murchison, or Professor Owen, or Professor Sedgwick, or Professor Huxley, or Mr Darwin, or Professor Faraday, or Mr Grove, or any of the other great men whom good boys are taught to respect. They are very wise men; and you must listen respectfully to all they say; but even if they should say, which I am sure they never would, 'that cannot exist': 'that is

> contrary to Nature,' you must wait a little and see; for perhaps even they may be wrong. Wise men are afraid to say that there is anything contrary to nature, except what is contrary to mathematical truth; for two and two cannot make five, and two straight lines cannot join twice, and a part cannot be as great as the whole, and so on (at least it seems so at present): but the wiser men are, the less they talk about 'cannot.' That is a very rash, dangerous word, that 'cannot'; and if people use it too often, the Queen of all the Fairies, who makes the clouds thunder and the fleas bite, and takes just as much trouble about one as about the other, is apt to astonish them suddenly by showing them, that though they say she cannot, yet she can, and what is more, will, whether they approve or not."

There is much sound wisdom underneath the fun of this passage, and the very pronounced change of attitude towards miracles of healing which has taken place in the last few years ought to be a further warning against dogmatic statements.

A distinguished psychotherapist gave me the following illustration some years ago. He was engaged, during the war, in the treatment of dumbness due to shell-shock. While actually engaged in this work someone brought to his notice a book by Dr Dearmer, in the appendix to which are quoted the accounts of two miracles performed by St John of Beverley (673-735). They are related by Bede, the narrative in the second case being in the patient's own words. The first was the case of a dumb man cured apparently by the making of the sign of the cross on his tongue. Reading the story with the mind and experience of the trained psychologist, however, my friend became convinced not only that the miracle had actually been performed, but also that the original narrator had seen it performed. The accompanying psychological treatment was exactly on the lines on which he and others had successfully worked. The second case was the healing of a paralysed man, ostensibly by blowing in his face. Here again, in the detailed personal account, my friend saw the psychological factor at work. A few days later an orderly was brought down from the trenches completely paralysed. My friend blew in his face (for a reflex !) and cured him. Two miracles of the type pilloried by Lecky and others as impossible, and both repeated by a psychologist during the war as part of his day's work.

Of course we seem to be much more puzzled over certain other types of miracles than our immediate ancestors could have been over miracles of healing : but this does not obviate the need of great caution. Nor does it obviate the even greater need for a clear statement of what the modern Christian means by a miracle or a supernatural event.

It may mean that the miracle is different in kind from natural happenings. This is merely equivalent to saying that it will always defy description in terms of the natural laws which science uses for the purpose. This possibility is one which science may be unwilling to admit, but can certainly not deny. Modern science admittedly knows no reason why a sequence should not be broken. When pressed, it is careful to emphasise that the necessity which seems to characterise the sequence is in our thought and only by inference in the phenomena themselves.

" Logical necessity has its habitat in the domain of thought alone. It binds together the parts of a fully worked-out conceptual scheme which represents a physical sequence, but no such necessity connects the successive stages of the physical sequence itself. For there exists no logical necessity that the theory should be applicable to the description of the phenomena : such applicability, when it exists, is a fact of experience only, not a necessity of thought."[1] While this is true, the mere fact that sequences do recur, entitles us to infer the existence of some kind of necessity in phenomena which is symbolised in the necessity of our physical laws. Science has no right, however, to rule out *a priori* the possibility that the relatively settled order with

[1] Hobson, *The Domain of Natural Science*, p. 80.

which it deals may on occasion be disturbed by events which not only cannot immediately be described under known laws and relationships, but permanently defy this kind of treatment. The difficulty is that, in the case of any well-attested unusual happening, it is always open to science to maintain that it will one day succumb to natural explanation, and equally open to theology to assert the contrary, without any possibility of decision being reached. If a miracle, then, differs from other events in being divinely caused in a special sense, there is no criterion by which we can recognise it.

The second possibility is that we may regard miracles as hitherto unexplained events which will presently become intelligible, as many of the healing miracles of Christ have already become. With this view science has obviously no quarrel, and it has high ecclesiastical sanction. According to the Bishop of Birmingham,[1] "Miracles in the New Testament are 'signs' of God's presence and power, not breaches or suspensions of the laws of nature." And the Bishops of the Anglican Communion in 1908 described the idea that miracles are such breaches or suspensions as an "oft-repeated misapprehension." They claimed, in effect, that if our knowledge of the universe were sufficiently extended we should understand the mechanism by which the miracles of the Gospels were worked. It is certain, however, that on this view miracles cannot claim to possess quite the same evidential value which theology once attributed to them. And it is perhaps open to question whether their real importance has ever been so great as Christian people have from time to time imagined. It is only in so far as the miracles are a self-revelation of Jesus that they have value. Turning the stones into bread or casting himself down from the pinnacle of the temple, even if they had been established as happenings of an unnatural kind, would have had no religious value. In the same way if all the miracles of Jesus had been actually performed by a man known otherwise as a rogue they would not have inspired our faith. If the temptations of Christ have any meaning there must have been miracles which it would have been wrong for him to perform or circumstances in which it would have been wrong to perform them. And so far as the evidence of the Synoptic Gospels goes, Jesus seems to have been very anxious to discourage a faith which rested on the mere externalities of miracle. We may frankly admit that Höffding is right when he says that whereas miracles " which in former times were a proof and support of religion, are now rather a stumbling-block which its apologists have to defend." For most Christian people to-day it is Christ who makes many of the New Testament miracles credible—not the miracles which accredit Christ and attest his message. But this change of view is not due to any logical clash with modern science. So far as modern science is concerned the miracle in the first of the above senses runs counter to the methodological axiom of science that all things can be explained, but otherwise it has a free course. To miracle in the second sense science has nothing to say. But it is possible that the Archbishop in *St Joan* was expressing a deeper truth than he knew in his cynical definition of a miracle: "A miracle, my friend, is an event which creates faith. That is the purpose and nature of miracles. They may seem very wonderful to the people who witness them and very simple to those who perform them. That does not matter: if they confirm or create faith they are true miracles." It is indeed by its spiritual character that the supernatural is to be recognised and the most ordinary happenings may sometimes produce the strongest spiritual impression. "As here used the supernatural means the world which manifests more than natural values, the world which has values which stir the sense of the holy and demand to be esteemed as sacred. This is the only way in which the distinction can be drawn, but in this way we draw it quite simply every day. We cannot distinguish the natural as the mechanical and the supernatural as the free, for we do not know how much freedom there is in the natural, or how much law in the supernatural: nor can it be divided as between the ordinary and the miraculous, for nature is sometimes the more miraculous, and the supernatural the common stuff of our daily experience. The two are not in opposition, and are constantly interwoven, and there may be nothing wholly natural or wholly supernatural, but our interests in them are perfectly distinct, and very definitely distinguish aspects of our experience."[1]

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[1] *Challenge*, June 22, 1923.

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[1] Oman in *Science, Religion and Reality*, p. 297.

CHAPTER VI

MECHANICAL DETERMINISM

THE greatest revolution in thought which the rise of physical science has brought about is the change which has taken place in our ideas of the relation of man to nature. Pre-scientific thought was homocentric. The animal and vegetable world existed to supply man's needs, the rain fell to water his crops, the sun shone to give him heat and light. We see this view of the world in one of the arguments, already quoted, against Galileo's discovery of the satellites of Jupiter. "They are invisible to the naked eye, therefore can have no influence on the earth, therefore are useless and therefore do not exist." In modern scientific thought the order of importance is reversed. Nature is the real and the primary thing. Man is a late arrival, almost if not quite a product of nature and playing a somewhat obscure part as a world spectator.

The beginning of the process by which this revolution has been effected is implicit in the thought of Ptolemy and explicit in that of Copernicus. Ptolemy's avowed intention was to represent the motions of the heavenly bodies by the simplest geometrical scheme which would "save the facts." His defect was that he could not conceive the earth as being involved in this scheme otherwise than as the fixed centre of it. But what Ptolemy's fixed ideas prevented him from doing, Copernicus achieved. He too was after mathematical simplicity. "*Natura semper agit per vias brevissimas.*" "*Natura nihil facit frustra.*" "*Natura neque redundat in superfluis neque deficit in necessariis.*" Copernicus includes a possible motion for the earth in his general scheme and produces one very much simpler than that of Ptolemy. He defends it as representing the motions of the planets by "*paucioribus et multo convenientioribus rebus.*" He regards the scheme as a legitimate method of representation, but probably not in any other sense as true. In the case of Kepler, however, we find a further step. He, too, magnifies simplicity. "*Natura simplicitatem amat.*" "*Numquam in ipsa quicquam otiosum aut superfluum exstitit.*" "*Natura semper quod potest per faciliora non agit per ambages difficiles.*" But for Kepler the true nature of the world is mathematical, and especially geometrical. God is the great Geometer. Mathematical simplicity and harmony is the test of truth and the cause of things being as they are. It was his vocation in life to search out these underlying mathematical harmonies—some of them quite artificial and useless. He had an idea that the orbits of the six known planets might be represented by six spheres arranged in a concentric series with the five regular solids between—the first sphere being inscribed in the first solid and the second sphere being circumscribed about this solid and so on. He says: "The intense pleasure I have received from this discovery can never be told in words. I regretted no more the time wasted; I tired of no labour; I shunned no toil of reckoning, days and nights spent in calculation, until I could see whether my hypothesis would agree with the orbits of Copernicus or whether my joy was to vanish into air."[1]

The next advance is made by Galileo. Applying to small terrestrial masses the ideas applicable to the planets and investigating the "How" of the falling body, he is compelled to give a new prominence to the concepts of space and time, and as a result of his work the world begins to look very like a system of bodies moving in space and time with cause residing in atomic motions and God as a huge mechanical inventor. This view was firmly established by the work of Newton. He and Boyle and all the other members of this great succession were convinced of the necessity of God on *natural* grounds in addition to their discovery of Him in their religious experience. But they required Him only as a First Cause, and for occasional subsequent repairs. Apart from this, God had no place in the natural, man had an entirely subordinate place and the real world consisted of masses in motion in time and space. This position was severely criticised by Leibnitz. "According to their doctrine, God Almighty wants to wind up His watch from time to time, otherwise it would cease to move. He had not, it seems, sufficient foresight to make it a perpetual motion. Nay, the machine of God's making is so imperfect, according to these gentlemen, that He is obliged to clean it now and then by an extraordinary concourse, and even to mind it as a clockmaker minds his work: who must consequently be so much the more unskilful a workman as He is oftener obliged to mend His work and set it right. According to my opinion, the same force and vigour always remains in the world, and only passes from one part of matter to another agreeably to the laws of nature and the beautiful pre-established order. And I hold that when God works miracles, He does not do it in order to supply the wants of nature, but those of grace. Whoever thinks otherwise, must needs have a very mean notion of the wisdom and power of God."[1]

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[1] Lodge, *Pioneers of Science*, Chap. III.

The step from regarding the motions of large or small masses as an aspect of the real world to regarding them as alone constituting reality was made by Laplace, and he may be regarded as the man who has made mechanical determinism explicit. He writes:[2] "We ought then to regard the present state of the universe as the effect of its antecedent state and as the cause of the state that is to follow. An intelligence, who for a given instant should be acquainted with all the forces by which nature is animated and with the several positions of the beings composing it, if, further, his intellect were vast enough to submit those data to analysis, would include in one and the same formula the movements of the largest bodies in the universe and those of the lightest atom. Nothing would be uncertain for him: the future as well as the past would be present to his eyes."

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[1] Brewster, *Life of Newton*, Vol. II., p. 285.

[2] *Essai philosophique sur les probabilités, p.* 4.

Now the attractiveness of this hypothesis to the scientific mind is obvious. It is based on the methodological axiom on which all science is founded. It is true that Mach claims that the order which science reveals is a creation and not a discovery. To him law is a form imposed by the human mind on the diversity of nature in order to make phenomena manageable. Most of us would say with Newton: "How wonderful is the order of the heavenly bodies that their movements may be all summed up in the Law of Gravitation." Mach says: "How wonderful is the mind of a Newton that it can invent so simple a formula to cover such a diversity of phenomena." Now Hume familiarised us with the view that science discovers no necessity in nature. We can assert that in the past heavy bodies have always tended to fall. We cannot assert that heavy bodies *must* tend to fall. But, while we may admit that the necessity of a sequence resides in its statement, it is difficult to believe that in nature there is nothing which corresponds to the logical necessity of the law, and not even a relatively settled order.

The question which we have now to ask ourselves is, How far can our knowledge of natural science be legitimately used as the basis of a philosophy which assumes the world to be a closed mechanical system in which all thought and activity is merely a manifestation of molecular agitation, and therefore mechanically determined, like the path of a ball on a billiard-table. On this view the world is a great machine relentlessly performing a fixed series of sequences and moving on towards an inevitable and predictable finish, while we ourselves are mere cogs in the machine following predetermined courses and working out a prearranged drama to its inevitable conclusion. We may note in passing that this view runs counter to one of the most marked characteristics of all our experience—the immediate conviction of freedom. This conviction *may* be an illusion, but it is important not to abandon it without strong reason, and when we get an apparent clash between an immediate conviction and the conclusion of a highly-sophisticated mental process it is by no means clear that the former ought to be sacrificed. I think it was Ruskin who claimed to have settled the controversy for himself once and for all by running downstairs several times and convincing himself in the process that even God had no idea whether he was going to finish a run by a jump of two steps or three. Some of us may not feel that the controversy is quite so easily settled, but, at least, we share Ruskin's conviction that, in matters of the kind he chose for illustration, we are free agents.

Then again we must consider the fact (a discouraging one in the circumstances to both the writer and his reader) that on the determinist view all argument is merely a colossal waste of time. A man may be a determinist but his determinism is as much determined as anything else in the world. He cannot be a " convinced " determinist in the sense that he has had to make a free mental choice after balancing the arguments. In fact, if the determinist claims that his philosophy is true, then the sense in which that much misinterpreted word is used requires more investigation than it has so far received.

Nor must we overlook the problem of knowledge with which this view faces us. It almost seems as if in their absorption in the conquest of nature by mathematical principles, thinkers were forgetting that the being who was gaining this knowledge and victory must, by that very achievement, be a rather remarkable creature. The semi-isolation of parts of this great mechanical system which can contemplate it, think about it and investigate it, constitutes a very real difficulty.

To most people, of course, the fundamental difficulty is that the philosophy seems to deny responsibility and seriously to modify all human relationships. It appears to create an atmosphere in which neither moral nor religious ideas can survive, and to reduce thought to the level of a mere epiphenomenon. It is not my business here either to elaborate the case against determinism along these lines or to discuss the attempts that have been made to reconcile determinism with morality, responsibility, rational thought, etc. If these accommodations can be effected, the conflict between determinism and religion will be profoundly modified, if indeed it does not altogether disappear. My business is rather to assume for the moment that determinism is really, as most people think, in irreconcilable conflict with religion, and then to consider the scientific case to be made out in its favour.

If we examine critically our own experience, we find that our conviction of freedom is a conviction of *limited* freedom:[1]

(*a*) We are only occasionally conscious of exercising it. Most of our conduct is carried on by fixed habits.

(*b*) Our choice of possible courses of action is limited to two or three possibilities.

(*c*) These possibilities are not arbitrary but are quite definitely related to, and

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[1] Cf. Schiller, *Studies in Humanism.*

> arise out of, the circumstances of the moment.

Thus the claim is not for a complete indeterminism, but for some limited amount of real freedom of choice.

With these facts in our mind we may now proceed to consider the question from the scientific point of view.

In the first place we may ask whether our scientific knowledge leaves us free to entertain the suggestion that in living organisms there is some directing principle which controls and modifies the inorganic happenings in the organism. This is the basis of the various " vitalist " theories which have been advanced from time to time. It is an attempt to come to terms with determinism on the basis of a delimitation of territory and to map out spheres of influence in which spontaneity and determinism might severally hold undisputed sway while recognising their respective limitations. On this view inanimate matter is handed over entirely to rigid sequences, but life reveals a vital principle modifying and controlling the mechanical processes.

The main difficulty which suggests itself in connection with this view is that we have no conclusive evidence of any interference with the laws of physics and chemistry and the successes achieved by biochemistry and biophysics point strongly in the opposite direction. The law of conservation of energy holds for the processes of an organism just as it holds in Joule's experiment. This difficulty may be evaded by thinking of the vital principle as merely directive. A force which acts always at right angles to the motion of a particle alters the path of the particle, but does no work on it. The energy of the particle remains constant. Even here, however, the momentum is continually being changed.

An idea certainly deserving of more consideration arises out of a problem first brought into notice by Poisson, the great French mathematician. He says: "The movement in space of a body under the action of a given force and starting from a given position with a given velocity must be absolutely determined. It is then a sort of paradox that the differential equations upon which its movement depends may be satisfied by several solutions." Clerk Maxwell returns to this "Paradox of Poisson" in discussing determinist systems, and the subject has been treated at considerable length by Boussinesq.[1] In an interesting passage dealing with the case of a heavy particle describing a smooth curve under gravity he shows that points may occur in its path where the particle may stop for any time and from which it may start in either direction, the moment and method of its departure being determined arbitrarily by a directing principle. Points of this kind which he calls " points of arrest " may be the seat of an eternal directing principle, the regions where its power is localised and the only regions where it can be exercised. A particle at rest on top of a smooth sphere is another example. It can be set in motion in any direction down the sphere at any time without the expenditure of any energy or the communication of any momentum.

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[1] See Bibliography.

I do not wish to stress this interesting suggestion unduly. I leave the question of vitalist theories with the proviso that they have in their favour at least the negative evidence that there are in our experience very large and very important tracts where no serious attempt has yet been made to apply the methods of physical science and that to claim the universal validity of the methods in our present state of knowledge is to make a gigantic extrapolation for which there is no very strong warrant. Indeed, not only does there exist this anarchist territory, but even where laws are successfully used for descriptive purposes their accuracy is never exact.

This brings me to a much more radical scientific criticism. We arrive at our evidence for a deterministic scheme of things only as a result of the process of abstraction which we have already seen to be an integral part of the method of physical science. Thus mechanism may be a universal feature and still be only a subordinate feature. The explanation of organic activity in terms of mechanism may be a true account and yet an incomplete account. This point is strongly stressed by Professor Haldane.[1] He expects organic processes to be capable of description in terms of physics and chemistry, but he regards such description as, by its very nature, inadequate; and many biologists have been driven to admit this inadequacy whenever the organism is regarded as a whole. Professor Arthur Thomson has given expression to a similar thought when he said that a self-stoking, self-repairing, self-increasing, self-reproducing machine is only by an abuse of language spoken of as a machine at all.

Looked at from another point of view, we have seen that, in the formation of the concept which lies behind the mechanical explanation, the concrete and individual elements of experience are minimised and the individual peculiarities of perceptual objects are overlooked. This is the real strength of the scientific method for its own purposes and its fatal weakness as a complete explanation. Scientific determinism, like mathematics, is a product of the abstractness of the scientific method. Mathematical methods can only be applied to a collection of identical units. We can only count oranges by regarding their individual differences as irrelevant for the purpose in hand. Mechanism involves us in ignoring the individuality of the real thing and determining what happens in each case by neglecting the individuality of the concrete and particular and dealing with the ideal and general. It is not a question of reducing everything to matter in the old sense. The revolt against materialism is not helped by the dematerialisation of matter. It is true that matter has been replaced by electric charges, and that in the recent (1926) work of Heisenberg and Schrodinger it is difficult to say what kind of "what not" is the unit of matter as we know it. We do not get rid of materialist difficulties by leaving the atom as a complicated equation except that we make it clear that it is our creation. The scientific method can no more discover something that is not determined than a man can discover red flowers in a field when he views it through blue glasses. The limitation of the method is not one of area, but of depth. There is no sacred realm of experience which is forbidden to the physicist; he is not asked to pass a self-denying ordinance. He is right to press his method in every direction and all his discoveries will be gains. When he claims to tell the truth and nothing but the truth we must be prepared to concede his claim—it is only when he claims to tell the whole truth that we enter a caveat. Readers who desire to pursue this interesting and fundamental aspect of the subject further are referred to the literature in the bibliography. We shall close this chapter with a quotation from Eddington,[1] putting a longer and more technical quotation from Collingwood[1] as an Appendix.

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[1] *Life, Mechanism and Personality.*

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[1] *Space, Time and Gravitation.*

> "The theory of relativity has passed in review the whole subject-matter of physics. It has unified the great laws which, by the precision of their formulation and the exactness of their application, have won the proud place in human knowledge which physical science holds to-day. And yet, in regard to the nature of things, this knowledge is only an empty shell—a form of symbols. It is knowledge of structural form and not knowledge of content. All through the physical world runs that unknown content, which must surely be the stuff of our consciousness. Here is a hint of aspects deep within the world of physics and yet unattainable by the methods of physics. And, moreover, we have found that where science has progressed the farthest, the mind has but regained from nature that which the mind has put into nature. We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after another, to account for its origin. At last we have succeeded in reconstructing the creature that made the footprint. And lo! it is our own."

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[1] *Speculum Mentis.*

Appendix to Chapter VI

" Scientific determinism is, like mathematics, a product of the abstractness of the scientific consciousness. Mathematics implies the ideal reduction of what are really unique individual facts to mere units; mechanism implies the ignoring of the omnipresent individuality of the real and the imposition upon it of an abstract law which determines every case indifferently from the outside. A further product of the same process is materialism. Matter is not that which we sensate, the visible, tangible and so forth, but that which in its indifferent self-identity underlies all immediate objects of sense. Matter is, in fact, as Berkeley once for all pointed out, the substantiality or reality of objects conceived as transcendent with regard to the objects themselves. It is sometimes fancied that modern physics, with its tendency to resolve gross matter into energy, events or determinations of space-time, is in process of overcoming materialism by its own dialectic. This is not so. The essence of materialism, its assertion of an indifferently self-identical substrate behind the variety of empirical fact, is unchanged, whether this substrate be called matter, energy, or space-time. Materialism is a logical phenomenon, it is the indifference of the abstract universal to its own particulars; and all the popular and philosophical objections to it rest upon this fact and are unaffected by the ‘dematerialisation’ of matter. In fact, the old-fashioned gross matter was a mark of incomplete materialism, for its grossness was just a relic of sensible qualities not yet extruded from the pure concept.

“Hence it is idle to imagine that materialism is justified in some sciences and not in others. It is idle to protest that science ought to surrender its materialistic prejudices when it finds itself face to face with a non-material object such as the soul. No object is material, in the metaphysical sense of the word, except so far as scientific thinking conceives it so; for materiality means abstractness, subjection to the formulæ of mechanical determination and mathematical calculation, and these formulæ are never imposed upon any object whatever, except by an arbitrary act which falsifies the object’s nature. This only appears paradoxical when we fail to see the gulf which separates the common-sense materiality of a table, its sensible qualities, from its metaphysical materiality, the abstract conceptual substrate of these qualities. It is this substrate whose transcendent or abstract existence is asserted by materialism. Hence, we cannot distinguish objects like tables which are really ‘material’ from objects in whose presence science must unlearn its materialistic habits of thought. Materialism is no more the truth in physics than in psychology and no less. It is the truth about any object, just in so far as this object is by abstraction reducible to terms of pure mathematics ; and no object is so reducible except by consciously or unconsciously shutting our eyes to everything which differentiates it from anything else. This conscious or unconscious act of abstraction is the very being of the scientific consciousness; and it is therefore no matter for pained surprise when science shows a bias towards determinism, behaviourism and materialism generally."

CHAPTER VII

CONCLUSION

In this chapter we shall endeavour to bring together the threads which have so far run through our study and to summarise the bearing of this study on our religious thought.

We have seen that it is claimed for science that it arose by way of satisfying a practical need. Man regarded his experience in the world of things and found himself driven to organise it if he was to live at all successfully and make the things subserve his purposes. Especially was it necessary for him to transmit to others the results of his own painfully-acquired experiments and observations. This could only be done by putting his knowledge in a form easily transmitted and easily apprehended. In response to this demand there came first the empirical law and then the scientific theory. Both are attempts to organise sense data—the first narrow and limited in its range, the second wider and more comprehensive. Armed with these, men have found it possible to communicate to their successors an ever-increasing body of knowledge, the results of which are to be seen in his ever-increasing conquest of nature and natural resources.

Now, in a sense, religion is also a response to a similar practical need. Man's experience is not confined to sense data. He has to live in a world which, on the face of it at least, is a moral and even a spiritual world as well. Just as successful living in the first of these worlds—or the first plane in the only world we know—involves a mastery of our material environment, so successful living in the world's wider aspects means mastery in the moral and spiritual realms also. There is no more reason for us to be the playthings of our moral environment than there is for us to be the sport of our physical environment. And one claim for religion certainly is that it is a guide to successful living.

But of course this explanation of natural science is quite inadequate and incomplete. Its practical usefulness may have played some part in its rise and progress, but most of its devotees would claim, I think, that this part has been a subsidiary one. With the greatest of its exponents the practical usefulness has, even subconsciously, been a quite subordinate motive. The desire to understand phenomena has been a much more powerful one. Sometimes, it may be, men have been misled as to how far real "understanding" was possible; but the impulse to relate, to connect, to systematise, to make intelligible, has been the really powerful one. The experience of finding a clue to an intricate mass of data, of hitting upon the unifying idea which makes it coherent, gives us a deep and poignant satisfaction which reveals at once the importance of the motive. This "understanding" of phenomena gives power and conduces to progress, but the power and the progress are secondary. So it is with religion. We want to understand life. We want to discover the great induction which will relate and give meaning to all its complex and puzzling experiences. And for many of us —particularly students—this is our first great demand of religion, that it should illumine life and make it a whole. For us—in so far as we are Christian—Jesus Christ must be the great induction. Unless his teaching and his life and death illumines our experience he cannot satisfy us. It is because and as we find that he does this that we put our trust in him. This is the foundation-stone of our religious faith. It corresponds to the first criterion of scientific truth. I have been at pains to show that we accept as true in physical science not what has been demonstrated by a logical process of reasoning, but what renders our phenomena intelligible and illumines them. I have heard the Master of Balliol[1] elaborate the same criterion for artistic and for historical truth. But it may be objected that in science we have a process called "verification." We have. But it is not a process for removing the theory into another realm and placing it in a category of infallibly true theories.

Newton's Law of Gravitation has been subjected to innumerable verifications. Yet, it seems probable that gravitation is a property of space, and not, as Newton thought, of matter. The demand for verification in science and the importance of it is that our true theory must not only illumine and make intelligible our *past* experience —it must do this for our future experience as well. This also we may fairly demand of religion. Our lives ought to be a continuous verification. We must not only understand the situations which have arisen in our past experience ; we must be equipped to meet new situations as they arise. This double criterion is undoubtedly our test of scientific truth, and I conceive it to be the *intellectual* test of religious truth as well.

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[1] S.C.M. Conference, Swanwick, 1926.

Two objections to this view are likely to form themselves in the mind of the reader. One, we have already touched on. If we have to some extent succeeded in putting religious truth in line with scientific truth, we have done so only by making the latter more doubtful and not by making the former more certain. Let us admit an element of truth in this at once. Uncertainty is present in all our theoretical knowledge, but we find scientific truth certain enough to act upon. And we find further that only as we walk in the light we have and use the truth which has been discovered, do we make progress to the wider and more complete truth. This certainly does make religion a voyage of discovery and not a harbour. It concedes the imperfections in the religious truth of to-day which most of us find so easily in that of earlier and especially Old Testament times. It does not necessarily mean that Jesus Christ is an incomplete revelation, but it does necessarily mean that our exploration of his revelation is incomplete. At the same time science does not proceed by a series of complete revolutions, or of entirely new starts. It is true that something of the old is always carried on and built into the new, and this certainly seems to be the case in religion as well. What we hold strongly and on the grounds stated may be imperfect, but only in that sense false.

A more serious objection which may arise in the reader's mind is that religion does not "illumine": that it leaves life full of difficulties and problems and dark places. Let us admit at the outset that the student-mind tends to exaggerate the importance of these, and that many of the problems and difficulties are highly artificial puzzles with no practical bearing on life. It still remains true that there are urgent practical problems upon which Jesus Christ throws some light, but which he does not solve. Life still has its dark shadows. Perhaps if we had the right attitude of mind we should not regard this with entire dissatisfaction. The scientist would hate to feel that he was coming to the end of his problems, and in religion we ought perhaps to rejoice that "the Lord has still more light and truth to break forth from his word."

After all, it is a question of the degree of illumination demanded. In the case of scientific theories dealing with a restricted range of data we are obviously justified in demanding a good deal; but if the theory is to cover all the facts of life we must surely be more modest. And here we may perhaps learn a valuable lesson from the scientist. One of the most interesting chapters in historical science is the rise of the modern view of heat. Two epoch-making discoveries were achieved almost simultaneously by Carnot and by Joule. Carnot assumed the indestructible nature of heat and his discovery of the "cycle of operations" which bears his name seemed to demand this as a basic fact. Joule, on the other hand, assumed heat to be convertible into other forms of energy, and his work was based on this view. Kelvin was probably the first physicist to realise the importance of Carnot's work and to bring it into prominence. When he heard Joule read his first paper to the British Association he was placed in an interesting position. Had his mind been closed, he would have taken the critical and depreciatory attitude to Joule's work which was characteristic of the scientists of the time. But his mind was open, and he found himself just as strongly impressed by Joule's work as he had been by Carnot's. Had he aimed immediately at consistency he would have rejected one view or the other. Heat cannot be both indestructible and destructible. Yet he felt Carnot's theory to be true and equally he felt Joule's theory to be true. Each illuminated a particular range of facts and each was therefore essentially true. What Kelvin in fact did was to hold on to both until in due time the apparent contradiction was resolved (largely through his own work) and it was found that heat was destructible, but that this destructibility in no way vitiated Carnot's theory. A similar, but even more acute, issue faces us in physics to-day. A large mass of data in the subject of light can only be related and made intelligible by regarding light as due to a spreading wave-disturbance. A different and ever-growing mass of data can only be adequately dealt with on the assumption first made by Planck, that light consists of little bundles of radiant energy called quanta, which are thrown off from the source and *do not spread*. Neither theory is applicable to the whole range of phenomena; each is admirably suited to its own part of the range. No sensible physicist wants to deny the essential truth of either. He believes the contradiction to be the result of imperfect knowledge, and he holds firmly to both, while seeking that deeper synthesis of which each is a part. The lesson of this surely is that the passion for logical consistency can be carried too far and that it can be achieved at too great a cost. It is an important lesson for the student mind. When an apparent contradiction in our thinking is revealed we must not idly acquiesce; there is something wrong somewhere. But, equally, we must not be impatient. It does not follow that one of the conflicting views is right and the other wrong. The short way to consistency is to choose one and deny the other, but this may be a very long way round to the truth.

It may be that this is the right way to deal with the apparent contradiction involved between determinism and freedom, and it is hoped that the preceding chapter has established good grounds for this. There is a range of our experience in which we act on a determinist belief, a fixed order of nature. There is another range in which we act as free. And I fancy it is the conviction of most people that this division is experimentally justified. If so, there is not the least justification at present for saying that one is the whole truth and the other must go.

So it is when attempts are made to force all the phenomena of our moral and spiritual life into the framework of the world as modern science presents it. Take, for example, the view put forward by Mr Bertrand Russell:[1]

> "Such in outline but even more purposeless, more void of meaning, is the world which Science presents for our belief. Amid such a world, if anywhere, our ideals henceforward must find a home. That man is a product of causes which had no prevision of the end they were achieving: that his origin, his growth, his hopes and fears, his

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[1] *A Free Man's Worship* (*Mysticism and Logic*), New York, 1918, p. 46.

> loves and beliefs, are but the outcome of accidental collocations of atoms: that no fire, no heroism, no intensity of thought and feeling, can preserve an individual life beyond the grave: that all the labours of the ages, all the devotion, all the inspiration, all the noonday brightness of human genius are destined to extinction in the vast death of the solar system and that the whole temple of Man's achievement must inevitably be buried beneath the debris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain that no philosophy which rejects them can hope to stand. Only within the scaffolding of these truths, only on the firm foundation of unyielding despair, can the Soul's habitation henceforth be safely built."

The reply to this is worked out in some detail by Mr Russell's friend and colleague, Professor Whitehead, in *Science and the Modern World*. It is surely a glaring instance of rejecting much that is true in the experience of each of us, and has been found true in the history of the race, to achieve a premature logical consistency. The assumptions and limitations of the scientific method do not at all justify the step, and when we ask ourselves whether it really co-ordinates, relates and makes intelligible all our experience of life, the answer must surely be in the negative.

Against that we may place the Christian view.

CONCLUSION

After we have allowed the New Testament critics to do their worst there emerges from the Gospels a perfectly clear-cut personality—the most arresting personality in history—with a definite body of teaching. His life and teaching are closely interrelated—unusually so—his life illustrates his teaching and his teaching illuminates his life. He is generally admitted to have been one of the most " victorious " personalities—so much so that he is usually placed in a category entirely by himself. He did not take his environment "lying down," he did not defy it, he mastered it. He claimed to know God and to reveal him as a God of love. He claimed for all mankind a special relationship to God, the only adequate description suitable to our apprehension being that of father and children. He claimed to live in the power of God, to survive death in the experience of men and to make the power of God available for others. As a testimony to the truth of his claims we have his own life and the lives of those who have taken him at his word most simply and sincerely—many of them conspicuous for their power, their victory and their joy. So much is not seriously disputed. Can we find elsewhere the same illumination of our experience, the same meaning in it? Can we find elsewhere the same verification in the business of successful living as we find not only in Jesus himself but also in those whom we judge to have been his most faithful followers? Is there not a plain case for surrendering ourselves to the same process of verification? We can, of course, make no sort of progress by accepting the Christian ethic and leaving it at that. To do so is to undertake a grim and joyless task with the certainty of final disappointment. Unless Jesus was completely and hopelessly mistaken, his own life was only possible through his experience of God, and his ethic is only possible for us through a similar experience. He claims to be not merely the truth about right living but the truth about the means for its successful accomplishment. The induction upon which we are called to act is not merely that the good life is the life lived and taught by Jesus, it is the whole view of God and the world and our fellow-men from which his life issued and in virtue of which the life was and is possible. Nay, more, it is the experience of Jesus revealed and described in his life and teaching, an experience to which he is at once the witness and the means of approach. Christianity *is* a philosophy of life, it *does* involve a theology, however simple. But it is fundamentally an experience of fellowship with God made possible by Jesus Christ. The venture in which we discover this experience may be justified intellectually, and the experience may—and to some extent must—be interpreted in intellectual terms; otherwise we cannot make it intelligible to ourselves or to others. The experience, however, is the fundamental thing, and it involves not only the intellect but also all those other aspects of personality which we abstract, and for convenience treat as separate entities, such as the emotions and the will. Our discussion has led us to the gateway, but discovery of the truth demands that essentially reasonable venture of faith which is the beginning of the knowledge of God.

QUESTIONS FOR DISCUSSION

CHAPTER I

1. In the past, the inerrancy of Scripture has been closely bound up with religion. Modern criticism has made the Bible a more complex book and parallel with this is the falling-off in interest in religion. Do you think the two phenomena are related to one another ? If so, does it follow that scientific methods of study ought not to be applied to the Bible ? What meaning can we now give to the phrase, " inspiration of the Holy Scriptures ? "

2. How far is the " method of creation," which this chapter is content to leave to the scientist to discover, a real difficulty for faith in that the story of evolution is a story of strife ? What difference to one's view of God and religion does belief in the theory of evolution make ?

3. Scientific knowledge seeks to order and formulate physical experience. Theology would claim to do the same thing for religious experience. Are the two on the same plane ? Is there the same element of truth and reliability in theological formulation as in science ? If not, is the difference in the kind of experience each deals with, or in the greater conservatism of theology ?

QUESTIONS FOR DISCUSSION

CHAPTER II

1. How does the view of Scientific Law outlined in the chapter affect the claim of Science that it *discovers* its laws in the Universe it investigates ?

2. " We never perceive motion." How, then, do we arrive at the conception of motion ?

3. Is the intuition that leads to the formulation of a Scientific Law analogous to religious experience ? What differences, if any, can you detect between them ? Can both be described as revelation ?

CHAPTER III

1. A scientific theory not only describes but suggests an explanation. What value has such an explanation ? Is it the only way to the discovery of causes, or is there reliable data outside the scope of science, *e.g.*, in religion ?

2. How far is it possible to decide between two rival theories by a crucial experiment ? What are the criteria by which we decide between theories both or all of which are capable of giving an explanation of the facts ?

3. Science rests on the fundamental belief in the "order of nature." On what does this belief rest—on perception, logical deduction, or on faith ?

CHAPTER IV

1. What significance do you attach to the activity of the human mind in formulating scientific laws ? Can a mind so active be itself subject to the laws it formulates ?

2. Does the recognition of the abstract nature of scientific law affect our view of the world as completely determined by law ?

3. Does the fact of individuality in the case of living organisms modify our view of Biology ? How far, if at all, can Biology take into account in its work the organism *as a whole ?*

4. The method of analysis can only provide an explanation of the complex in terms of the simpler elements composing it. Is such an explanation satisfactory ? Religion would interpret the whole in terms of the highest. Is this the real distinction between Science and Religion ?

CHAPTER V

1. How far can the uniformity of nature be construed as the trustworthiness of God ? What are the difficulties in the way of this view ?

2. Does the view that " the broken law is merely an inadequate description " leave room for " miracle," and what difference does it involve in our view of the miraculous ?

3. How far do the recent advances in psychotherapy (*a*) make miracles more reasonable ; (*b*) explain them away ; (*c*) merely extend the realm of Law ?

4. When we say that a law " holds " in certain phenomena, does this mean that the law is the most convenient description of events possible *for our minds*, or that the events themselves, indepen-

dently of our minds, obey that law? That is, is the element of "necessity" in the phenomena themselves or in the nature of the human mind? In either case, what light is thrown upon the nature of the "mind behind the Universe?"

5. What is the real value of miracles in religion? What part do they play in our belief in Jesus Christ? Do they create difficulties, and if so, is this due to a wrong attitude on our part to miracle or to the supernatural generally?

CHAPTER VI

1. On Mach's view the only "order of nature" is something which *we* impose upon the diversity of nature. If this be true, in what sense can we have knowledge of nature?

2. On the determinist view, we ourselves would be included as parts in the mechanical universe we investigate. What bearing has this theory upon the possibility of knowledge? Can that which is itself a part of the machine know and understand anything of the machine itself? Does this really deny all possibility of knowledge?

3. In actual life we assume freedom of choice and act upon this assumption. There is, however, a real sense in which our choices are determined—by habit, circumstance, past experience, etc. What importance can be attached to our immediate intuition of freedom?

4. How far is a " vitalistic " view of organism congruent with fact, and an explanation of freedom ?

5. Science can only proceed on the assumption of determinism. What account, then, can it give of reality ? Does the importance of things outside its scope, such as moral freedom and individuality, justify the view that Science can only give a partial account of reality which can be included in a religious view of the world, but which can never include it ?

CHAPTER VII

1. Both Science and Religion are to some extent responses to a practical need. What are the dangers inherent in this lesser conception for science ? Is there a utilitarian view of religion which is exposed to the same kind of dangers ?

2. What is the significance of the person of Jesus as seen in the Gospels ? Does it lie in what he taught—his ethics ? Or in his life, his relation to men ? Can you separate his teaching or his life from his own relationship to God and from the meaning he had for man's relationship to God ?

3. What view of God and of his relation to the world underlies the fact of Jesus Christ ? Can it take account of the findings of modern science, including them in itself, or is there a real conflict here ?

4. If we take Jesus as the " great induction " in the light of which to interpret life, what does this mean (*a*)

for ourselves; (*b*) for the way in which we regard him? Does it mean that in some sense his significance is so much beyond that of ordinary men that we can only speak of him as "divine"?

5. What is involved in the process of verification of religious truth suggested in the foregoing chapter? Can it have any of the detachment of scientific method? If not, just because it involves the whole self, is there not an element of urgency in religion that is necessarily absent from science?

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